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Progress Report on the Work for the Improvement of Sugar Cane Through Bud Selection.

By A. D. Shamel.

Introduction.

The studies of bud variation and bud selection in the work for the improvement of sugar cane by the writer and associates of the Experiment Station of the Hawaiian Sugar Planters' Association were begun in February, 1920. A brief preliminary report, covering some of the observations made during the spring of 1920, was published in the Hawaiian Planters' Record, Vol. XXII, No. 5, May, 1920. It has been deemed advisable to make a similar brief report of our observations during the season of 1921. No attempt will be made at this time to make a detailed report upon the progress of this work. Data are being accumulated and detailed observations are being systematically secured, showing the exact facts concerning the development and progress of the work, which will be available for publication as soon as this investigation has gone far enough to warrant final conclusions and recommendations. In the meantime, these brief annual progress reports may be of some value to those who are interested in this work and particularly to those who are cooperating or who are planning to cooperate in the practical application of sugar cane selection to plantation conditions.

Object.

The main object of our sugar cane selection work is to isolate and propagate the best strains of the important established and proven sugar cane varieties in Hawaii through the selection and propagation of superior parent plants. In other words, the object of this work is to preserve and improve the superior strains and eliminate the inferior ones of the commercially valuable varieties of sugar cane through systematic bud selection.

Plan of Work.

The plan of work adopted in this investigation has been to make system-

atic studies of performance record plats of sugar cane. These plats are located in the best available plantation fields of the established varieties under investigation. In these plats the characteristics of the individual stalks and stools are studied in a systematic and detailed way, in order to determine and establish definitely the characteristics of the variations and strains of each variety arising from them. This work requires patience, perseverance, and a natural inclination for this kind of study. It is of primary importance from the fact that it is through such studies that standards of selection, both for strains and individual plants in these strains, may be developed for practical field use in the work of locating and securing superior parent stools for planting progeny fields.

In this work, the term *individual plant* is used to define a stool of sugar cane. The term *stool* is used to define the stalks which have arisen from a single eye of the plant cane. In regular plantation sugar cane fields in Hawaii it is usually practicable to identify the individual stools by locating the primary, the secondary, and other related stalks in the case of one-year old plants. With two-year old plants, the identification of individual stools is more difficult. In order to study two-year old stools satisfactorily it has been found advisable to space the plant cane in the experimental and progeny fields so that the individual stools can be readily picked out and definitely located. The term *progeny field* is here used to mean a field planted with plant cane secured from superior parent stools selected by someone trained in this work. In the progeny fields, the progeny of each parent stool is kept together and identified in some way so that the behavior of the different progenies may be compared and, if desirable, traced back to their parent stools. The plantation progeny fields are used (1) for the selection of superior plant material for extending the progeny fields each year, and (2) as sources of superior plant cane for general plantation use. The parent stools selected in the progeny fields for extending these fields are secured by trained men. The plantation plant cane is secured in the progeny fields in the usual manner by ordinary plantation labor. When the plant cane is cut from the progeny fields for plantation use, the writer believes that it is advisable to throw out any small, deformed, or otherwise apparently inferior plant pieces and use only the large, well-developed, and apparently good ones. This plant material is undoubtedly much superior for planting the plantation sugar cane fields to that taken from the general fields where no selection has been practiced.

Observations Upon the Results of Planting Selected Stools.

During the planting season of 1920, experimental plantings of selected stools of sugar cane were made at the Waipio experimental plantation, the Ewa, Onomea, Honokaa plantations, and the Makiki plats of the Experiment Station by the writer and his associates. Other experimental plantings were made by members of the Experiment Station staff or under their supervision or by plantation managers on Maui. In most of these experimental plantings the progeny of each selected parent stool was kept together and arranged in the progeny fields so that it could be identified and studied whenever desirable. In the Waipio and some other plantings the progenies were staked and numbered so that each progeny could be traced back to its parent stool in order that the characteristics of each parent stool could be compared with those of the stools in its progeny.

In February, 1921, a study was begun of these progeny plantings by the following members of the Experiment Station staff: H. P. Agee, J. A. Verret, W. W. G. Moir, Y. Kutsunai, and the writer. Faithful and efficient services in this connection were rendered by Japanese and Filipino laborers, most of whom had participated in the planting of the progeny fields during 1920 and who had shown their adaptability for this kind of work. From time to time other members of the Agricultural Department of the Experiment Station staff than those mentioned above assisted in this field work as their duties permitted, including R. S. Thurston, W. L. S. Williams, and J. H. Midkiff. Mr. W. P. Alexander of the Ewa plantation, and other plantation officials displayed a keen interest in this work and actively assisted in its development upon their respective plantations. Through the active and sincere cooperation of all of the men involved, it was possible during 1921 to systematically study a considerable acreage of progeny plantings and secure definite information regarding the results of sugar cane selection work as a basis for drawing reliable conclusions as to the possibilities of this work for the improvement of the sugar cane industry in Hawaii.

At Waipio the progeny plantings were first gone over in a general way and the behavior of some of the most interesting progenies studied and compared. In this work the best and the poorest progenies were located. It soon became apparent that some of the progenies were very much superior to others in a number of important characteristics, including perfection of stand of stools, the number and size of stalks in each stool, the habit of growth of the stalks, the resistance of the plants to disease, and other important features of plant behavior. As soon as these facts were determined from observation and some comparative measurements, the progenies were then gone over systematically a second time and exact detailed records were secured of certain characteristics of each stalk of each stool in all of the progenies. It became evident in the first survey of the Waipio progeny plantings that in order to study the plantings as a whole within the time available for this purpose and with the limited number of men available for carrying on these studies, it would be necessary to confine the detailed records of plant behavior to a few important plant characteristics. After considerable thought and study of this problem, it was decided to limit these records during the 1921 season to the number of stalks in each stool, the circumference of each stalk, the type characteristics of each stalk, the comparative uniformity of stalks in each stool, certain eye characteristics, with notes upon the resistance to disease or other injuries or any other apparent plant characteristic which might have a bearing upon the inherent value of the plants for propagation. These extremely interesting and very valuable data will not be submitted for publication at this time and are being reserved for a detailed report upon this work when sufficient data have been secured to enable us to present the subject as a whole in a satisfactory manner to everyone concerned.

The individual stalk and stool data secured in the progeny plantings at Waipio were used in making up tables for several progenies showing the standard deviation and coefficient of variability for each progeny. These data enabled us to make definite comparisons of the behavior of the individual progenies and to rank them in the order of their performance from these standpoints. The data also made it possible for us to compare certain definite parent plant char-

acteristics with those of the progenies, in other words, determine the characteristics of the parent plants which were inherent and transmitted to their progenies. The figures secured in these progeny studies made it possible to lay the foundation for the establishment of certain definite standards of selection for parent stools of the varieties studied, a matter of supreme importance in the practical work for the selection of plant cane for progeny fields.

At Ewa it was not possible under the circumstances to make a detailed study of the 600 progenies of the H 109 variety in the progeny field on that plantation. This field was gone over systematically and 972 superior parent stools were selected and planted from it in an additional progeny field for that plantation. After the selected parent stools had been taken out of the Ewa progeny or mother field, the remainder of the stools were used for general plantation planting. This plant cane was apparently much better for this purpose than any that could have been secured from plantation fields where the plant cane had not been selected. A second progeny field of H 109, planted in 1920 on the Ewa plantation, was left for detailed study in 1922 in order to secure data upon the behavior of two-year old plants grown from selected parent stools.

The progeny field of the Yellow Caledonia variety on the Onomea plantation showed very striking results. Individual plant and progeny performance record data are now being secured in this field and selections of superior parent stools are being made for planting an additional progeny field during the present season. The progeny field at the Honokaa plantation, mainly of the D 1135 variety, will be studied during the present summer as opportunity permits, and individual plant and progeny record data secured as a basis for the selection of parent stools for planting an additional mother field. Similar work will be carried on with the Hilo Sugar Company's field of Yellow Caledonia, grown from selected parent stools, and with other similar plantings on other plantations on Hawaii and Maui.

The results of our studies of the experimental progeny fields planted in 1920, located at Waipio and upon several plantations, demonstrate beyond any question of doubt that greatly improved yields of sugar cane can be secured through the selection of superior parent stools as plant material. This increase in production is effected without increase in the cost of production other than that incurred in the selection of the parent stools for the progeny fields, and, therefore, makes possible a marked economy in sugar production and a correspondingly large gain in the profitableness of this business.

The parent stools having uniformly good stalks, selected and planted in 1920, produced uniformly good progenies in 1921, while the poor parent stools produced uniformly poor progenies. The parent stools having some good and some poor stalks produced progenies having some good and some poor stools. These facts establish beyond reasonable doubt in the minds of everyone who studied the progeny fields this season that sugar production can be improved through the selection and planting of superior plant material, i. e., uniformly good parent stools of the best strains in any of the varieties studied, and that this condition will enable the planters to increase their production per acre to a very important and marked degree. It is too early as yet to estimate the amount of the gain in the production of sugar per acre that may be secured

through the selection of superior plant cane, but it can be safely said that the data from the progeny fields planted in 1920 and harvested in 1921 indicate that this gain applied to plantation production as a whole will be more than 25 per cent.

Plan of Planting Sugar Cane Selections During 1921.

After the systematic study of the progeny plantings at Waipio and the analyses of the data secured therefrom, the plants of best progenies were used for planting additional progeny fields at Waipio of the H 109 and Yellow Caledonia varieties. In addition to the propagation of best progenies, a few of the poorest progenies in each variety were propagated for comparative purposes. Each seed piece of all of the stalks used for planting these progeny fields were arranged in the rows in such a way that the new plants from each of these seed pieces can be readily traced back to the parent stools and progenies at any time. In addition to furnishing invaluable data as a basis for sugar cane improvement work, these progeny plantings will provide a considerable amount of genuinely pedigreed plant material for plantation use.

The plants of a few of the best and a few of the poorest progenies at Waipio were propagated as single eye cuttings at the Makiki plats. The single eye cuttings were first planted in pots. When large enough, the young plants were transplanted to the field plats. The germination and growth of these single eye plantings from the carefully selected progenies furnished further positive evidence before they were transplanted of the importance of sugar cane selection. The eyes from the stalks from the good progenies produced a very high percentage of strong germination and the young plants showed a sturdy, strong growth of exceptionally fine appearance. The eyes from the poor progenies showed poor germination and produced spindling and apparently inferior plants. It is probable that from these single eye experimental plantings valuable genetic data can be secured as a basis for guiding selection work, as well as enabling us to measure the progress made through the isolation of the best strains and the selection and propagation of the best stools in these strains.

At Ewa, further selections from the progeny field of apparently superior stools of the H 109 variety were made and in addition to these propagations, Mr. Alexander and associates of this plantation are planning on adding to the progeny field by the additional selection and planting of superior parent plants from some of the best plantation fields.

At Onomea, after the data in the mother field of the progenies of Yellow Caledonia and some other varieties have been secured, plant material will be cut from the superior parent plants of the best progenies for an additional progeny field in order to increase the best progenies as rapidly as possible.

At Honokaa, similar work to that at Onomea will be carried out. At the Papaikou and Hilo Sugar Company plantations additional selections of superior parent stools will be made for the purpose of planting additional progeny fields. If time permits, similar work will be carried on upon plantations on Maui.

Summarizing planting plans for 1921, the experimental plantings made at Waipio and Makiki will furnish data as a basis for measuring the progress of

the work of cane selection and establish to some extent superior sources of pedigreed plant material of H 109, Yellow Caledonia, and two or three other minor varieties. At Ewa, Onomea, Honokaa, and other plantations, additional progeny fields will be established as sources of improved plant cane for these plantations.

Plan of Work for 1922.

During the 1922 season, it is planned to study systematically the experimental progeny plantings on the Waipio and Makiki plats and to secure systematic data regarding the behavior of these progenies. It is planned to devote considerably more time than has been possible heretofore to the establishing of standards for selection of parent stools in all of the varieties under consideration through the study of the behavior of the progenies of the selected parent stools in the progeny fields. This work is extremely important from the fact that before reliable selections of parent stools can be made, definite standards must be determined and agreed upon as to the characteristics of the strains and the stools in the strains for propagation in the progeny fields. It is planned for 1922 that as much time as possible will be devoted to active cooperation with plantations on Oahu, Hawaii, Maui, and Kauai, in order to cooperate with them in the planting of progeny fields as sources of plant cane to be used upon these plantations. In 1922 it will be possible to study the behavior of the two-year old stools in some of the progeny fields planted in 1920, thus enabling us to study the behavior of such plants, particularly their sugar content. It will also be possible to study the ratooning of some of the progeny fields which were harvested in 1921.

Summary of Observations.

The progeny fields studied this season show that some of the parent stools propagated in 1920 produced progenies having uniformly good stools, while others produced progenies with mixed or uniformly inferior stools. From a study of the parent stools and their progenies, we are led to conclude that the parent stools which had *uniformly good stalks* are the ones which produced uniformly good progenies, while the parent stools with one or more poor stalks produced the inferior progenies having good and poor or uniformly poor stools. The differences in production of the uniformly good progenies and that of the poor progenies were very large. The differences in the production of the good and the poor progenies were such as to demonstrate clearly the economic importance of adopting a system of selection in the planting of sugar cane fields. From the evidence secured in the progeny fields this year, the writer has come to the conclusion that greater progress will in all probability be accomplished in improving the production of sugar cane through the selection of superior parent stools of the best strains than has been effected heretofore in the improvement of any other crop through selection and breeding.

Distinct strains have arisen in the sugar cane varieties as a result of bud variation and have been propagated unintentionally by reason of the absence of any method for the systematic selection of superior plant material. Bud variation has been found to be of frequent occurrence in all of the varieties studied

and of great importance from the standpoint of maintaining the productiveness of the varieties which are commonly grown. Many of the sugar cane variations or mutations seem to be atavistic in nature and of inferior commercial value. For this reason the unintentional propagation of the strains arising from these undesirable variations is doubtless the primary cause of the running out or degeneration of the commercial varieties. Some of the variations are doubtless valuable and it seems likely that through isolating these valuable mutations through selection new and improved strains of the important varieties can be secured and maintained for commercial plantation use.

The isolation of the best strains in each of the valuable varieties and their maintenance and improvement through the systematic selection and propagation of superior parent stools having uniformly good stalk characteristics has been demonstrated to be practicable in the progeny fields under plantation conditions.

The standards of selection for parent stools of the best strains of each variety must be worked out through *experimental progeny plantings* and from a continuous and concentrated study of the individual stools, the *characteristics of the stalks of these stools, and the performance records of the progenies of carefully selected stools.*

It seems highly desirable and necessary that in the beginning of the practical application of this work the plantations desiring to adopt it should secure the assistance and cooperation of the men trained in this work from the Experiment Station staff. Several plantations have already offered the services of one or more of their employes, who will work with the Experiment Station men for a time, familiarizing themselves with the methods and practices used in the selection of superior parent stools for propagation in the progeny fields. These plantation men, after the necessary experience and training, will cooperate with the Experiment Station in the planting of progeny fields upon their respective plantations. This arrangement will provide one or more trained men on each plantation who will develop for their plantations reliable and superior sources of plant material for commercial use.

After the progeny fields have become established on a large enough scale to provide adequate plant material for general plantation use, the seed pieces can be cut in the usual way and the planting done as is the ordinary practice. The writer believes that after the seed pieces have been cut in the usual manner in the progeny fields, it will prove to be a desirable practice to throw out any apparently inferior seed pieces and plant only the good ones. This plan will undoubtedly eliminate one of the important causes of poor stands in the fields because the small or weak-looking seed pieces which under this plan will be thrown out and not planted are undoubtedly responsible for much of the poor germination and consequent poor stands sometimes observed. The study of this phase of sugar cane improvement has not gone far enough to warrant final conclusions as to its importance and value, but enough evidence has been observed to show that it can be safely followed with results which will justify the expense of doing it. In other words, in any general lot of seed pieces, such as those secured from progeny fields for plantation use, it now seems advisable

to throw out any apparently weak pieces in order to get an even and vigorous germination so as to secure the best possible stand.

Progeny tests of stools grown from seeds in the work for the origination of new varieties of sugar cane will likely prove to be of great importance in comparing the value of seedlings. In this way it seems probable that the methods of selection worked out in these studies can be used advantageously in the seedling work. These two lines should go hand in hand and both are of fundamental importance to the sugar industry from the standpoint of securing, maintaining, and improving varieties of cane for the production of sugar on the most economical and profitable basis.

Conclusion.

The results of the studies of the progeny plantings of the Yellow Caledonia, H 109, D 1135, and other varieties of sugar cane made in 1920 from selected parent stools demonstrate beyond any question that it is possible to increase the efficiency of these varieties for sugar production and, as a result, improve the yield of sugar cane per acre very materially through the selection and propagation of superior parent stools. This information furnishes the reason for sustained and continuous effort in order to perfect methods and standards of selection, to identify and judge the value of the different strains of each variety for commercial utilization upon the plantations in different districts, and to adapt the methods of securing and using improved plant material for plantation use. It seems likely to the writer that with proper support and cooperation on the part of the Experiment Station and the plantations, adequate supplies of superior sugar cane plant material for all plantations desiring it can be established within the next few years.

The work for the improvement of sugar cane through bud selection now being carried on by the Experiment Station of the Hawaiian Sugar Planters' Association may be classified as follows:

(1) The isolation and propagation of the valuable strains and the elimination of the inferior ones of the established varieties.

(2) The selection and propagation of superior parent stools of the best strains in progeny fields.

(3) Securing adequate supplies of improved plant material from the progeny fields for plantation use.

(4) Developing standards for parent stool selection through progeny tests of carefully selected stools.

(5) Searching for and trying out apparently valuable mutations for the origination of new and important strains and varieties of sugar cane.

(6) Determining the frequency of occurrence and the characteristics of bud variation in the varieties under investigation and the relation of the variations to sugar cane improvement.

If the U. S. Department of Agriculture gives the writer a furlough next year similar to that provided for the past two years, he will be glad to accept the invitation of the Director of the Experiment Station and the Experiment Station Committee of the Hawaiian Sugar Planters' Association in order to continue his part in this work during 1922.

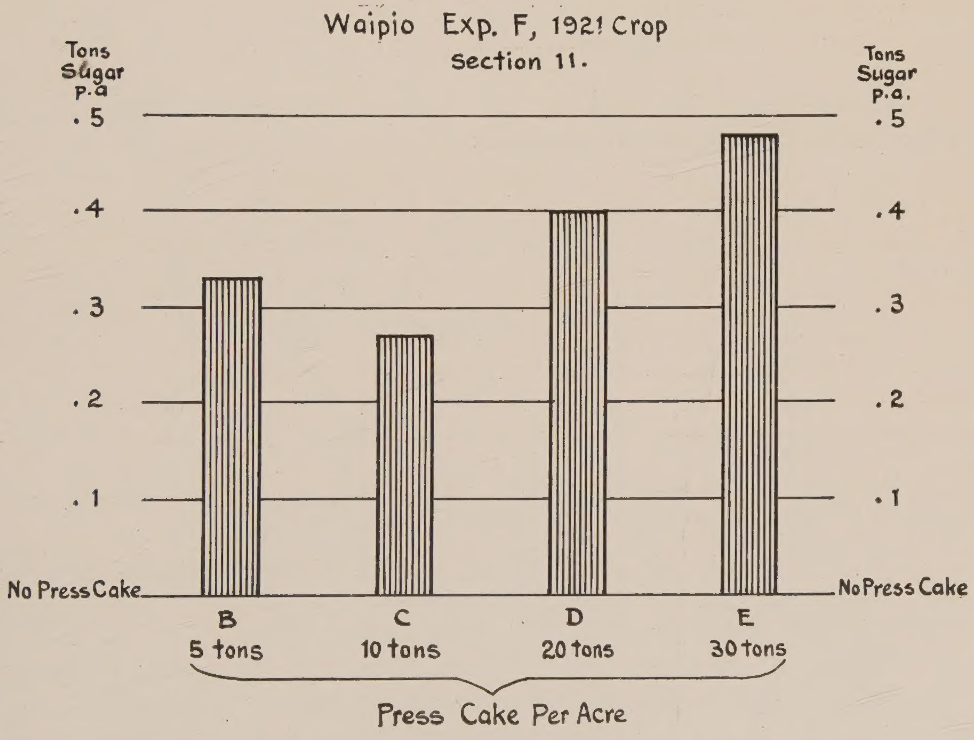
The Fertilizing Value of Press Cake.

Waipio Experiment F, 1921 Crop.

This was an experiment to determine the fertilizing value of varying amounts of press cake used in addition to commercial fertilizers.

The cane was H 109, second ratoons, long, and was 21 months old when harvested. This field had not been irrigated this year, having been carried over from the winter rains. The field was harvested at the end of April. The quality ratio of the juices was 8.24.

Chart Showing Gains Due To Varying Amounts Of Press Cake.



In addition to press cake 1740 pounds of nitrate of soda was applied to all plots.

All plots received a uniform application of nitrate of soda consisting of 1740 pounds per acre. Of this 1160 pounds were applied in August, 1919, and 580 pounds in February, 1920.

The amounts of press cake used and the yields obtained are given below:

No. of Plots	Pounds of Press Cake per Acre (In addition to 1740 pounds of Nitrate of Soda)	Tons per Acre	
		Cane	Sugar
11 A	No Press Cake........................	104.4	12.67
11 B	5 tons Press Cake....................	107.1	13.00
11 C	10 tons Press Cake....................	106.6	12.95
11 D	20 tons Press Cake....................	107.2	13.07
10 E	30 tons Press Cake....................	108.4	13.15

The mud press cake used in this experiment had the following composition:

Water	= 74.18%
Nitrogen	= 0.36%
Phosphoric Acid (P_2O_5)	= 1.13%
Potash (K_2O)	= .12%

The amount of plant food in pounds per acre from the mud press cake applied to the different plots is as follows:

	Nitrogen	P_2O_5	K_2O
A plots	None	None	None
B plots	36	113	12
C plots	72	226	24
D plots	144	452	48
E plots	216	678	72

The press cake was placed in a shallow trench alongside the cane and covered by hand, the dirt being taken from the opposite side of the row.

The press cake in this case increased the yield of cane by about 3 tons per acre, and the sugar by 0.35 ton. This increase was produced by 5 tons of press cake per acre. Larger amounts produced no further gains.

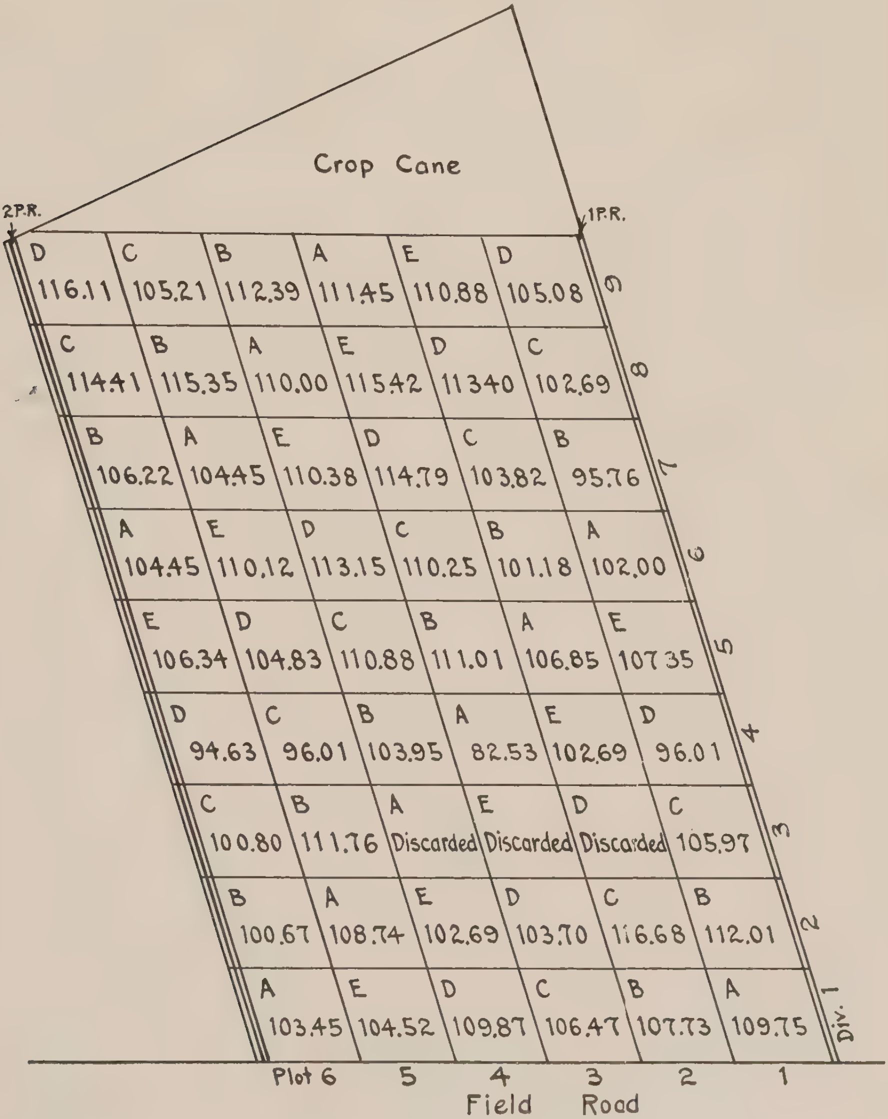
These results are about the same as those reported in the July, 1921, Record, from Waipio experiment U. In experiment U, 10 tons of press cake increased the yield of H 109 9.2 tons of cane per acre when no other fertilizer was used, but when 1740 pounds of nitrate of soda were applied in addition this gain dropped 2.4 tons of cane.

This experiment is being continued to note the effect of press cake on the soil when applied through a series of years.

FERTILIZING VALUE OF PRESS CAKE

Waipio Exp. F, 1921 Crop

Section 11.



Summary Of Results

Plots	No. of Plots	Treatment	Tons Per Acre		Gain or Loss Over "A"
			Cane	Sugar	
A	11	No Press Cake	104.37	12.67	0
B	11	5 tons Press Cake Per Acre	107.09	13.00	+ .33
C	11	10 " " " " "	106.65	12.94	+ .27
D	11	20 " " " " "	107.16	13.07	+ .40
E	10	30 " " " " "	108.38	13.15	+ .48

DETAILS OF EXPERIMENT

Waipio Substation — Experiment F, 1921 Crop.

Mud Press Cake Test.

Object:

(1) To test the fertilizing value of mud press cake.

(2) To compare the yields from varying amounts of mud press cake.

Location:

Waipio Substation — Section 11.

Crop:

H 109, second ratoons, long.

Layout:

Number of plots: 54.

Area of each plot: 1/30 acre (net).

Number of rows per plot: 8.

Plan:

Mud press cake to be applied as follows:

A plots	None	D plots	20 tons per acre
B plots	5 tons per acre	E plots	30 tons per acre
C plots	10 tons per acre		

Fertilization — uniform:

August 19	1160 pounds Nitrate of Soda
February 20	580 pounds Nitrate of Soda

J. A. V.

New Seedlings at Hakalau.

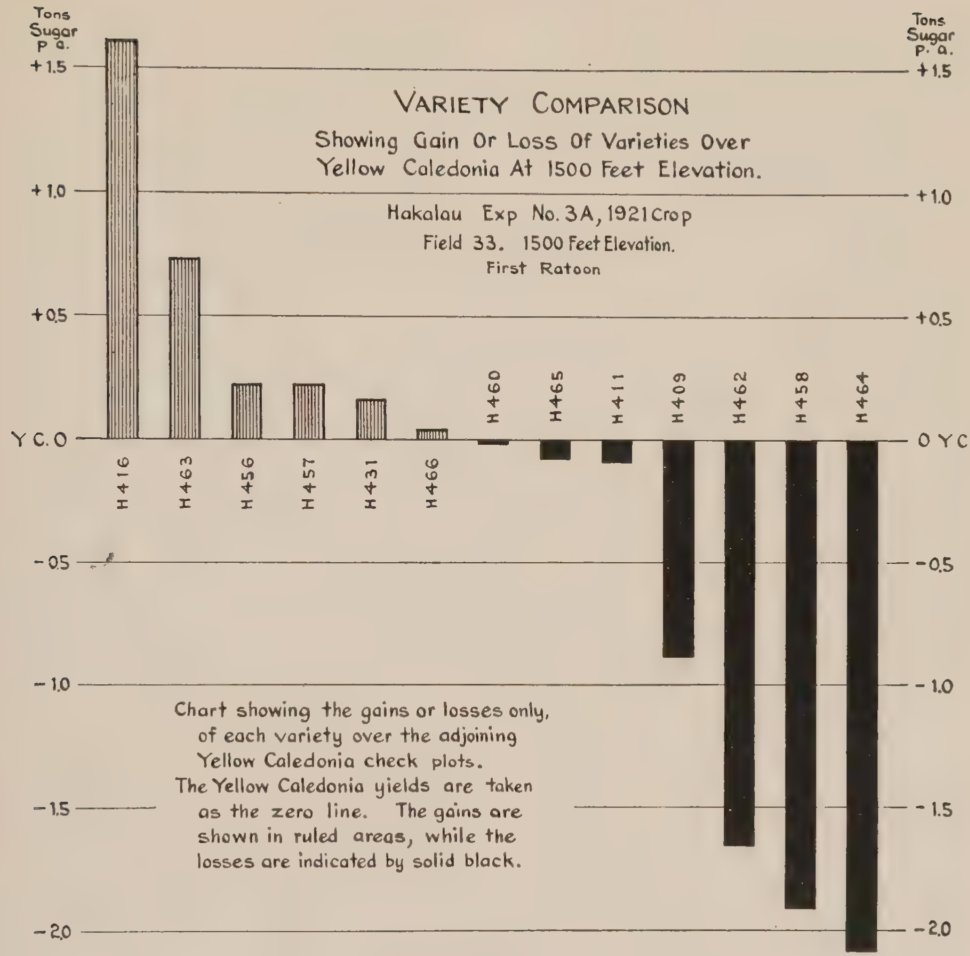
Hakalau Experiments 3a and 3b.

These experiments compare the standard variety of cane, Yellow Caledonia, with 15 new H seedlings at different elevations. Experiment 3a is at an elevation of 1500 feet, while 3b is at an elevation of 400 feet.

Two crops have now been taken off, one plant and one ratoon. In experiment of 3b at 400 feet elevation none of the seedlings were as good as Yellow Caledonia. The ratoons were especially poor. So poor, in fact, that it was not considered worth while harvesting the experiment.

In experiment 3a at 1500 feet elevation the results were different. Several of the seedlings gave distinctly better yields than the adjoining Yellow Caledonia. This held good for both the plant and the ratoon crop.

The yields obtained at 1500 feet elevation are reported in the following table:



EXPERIMENT 3A

Varieties in Order of Gain or Loss Over Yellow Caledonia, Field 33; Elevation 1500 feet.

Variety	Tons per Acre		Gain or Loss Over Adjoining Yellow Caledonia Plots	
	Cane	Sugar	Cane	Sugar
H 416	50.5	5.38	+ 16.9	+ 1.61
H 463	43.1	4.68	+ 7.9	+ 0.73
H 456	43.8	4.99	+ 1.3	+ 0.22
H 457	53.3	5.10	+ 9.8	+ 0.22
H 431	36.7	4.40	— 1.1	+ 0.16
H 466	36.8	4.59	— 3.7	+ 0.04
H 425	40.3	....	— 0.1	....
H 460	42.7	4.50	+ 2.4	— 0.02
H 465	37.0	4.42	— 3.1	— 0.08
H 411	32.5	3.73	— 1.5	— 0.09
H 409	41.0	4.50	— 7.0	— 0.89
H 462	24.2	2.45	— 12.4	— 1.66
H 458	43.2	3.84	— 8.0	— 1.91
H 464	22.9	2.30	— 16.2	— 2.09
H 427	12.3	....	— 18.7	....

In the table below are given sugar yields for the two crops, with their combined gains over the adjoining Yellow Caledonia, of the five leading varieties.

Variety	Tons Sugar per Acre		Gain Over Adjoining Yellow Caledonia
	Plant	1st Ratoon	
H 416	4.31	5.38	+ 2.96
H 457	6.37	5.10	+ 2.08
H 456	6.61	4.99	+ 1.97
H 463	3.87	4.68	+ 1.97
H 431	4.87	4.40	+ 0.63

Four of the above varieties, especially, are promising, and well worthy of further trial. We plan to lay out a larger experiment at Hakalau as soon as the ratoons from this harvest are big enough to cut for seed.

We note in the above table that H 416 and H 463 produced more sugar from the ratoons than from the plant crop. This indicates good ratooning qualities; something very important when considering varieties for mauka lands. The results of these two experiments, carried through two crops, show the great importance of trying out new varieties of cane under all conditions that obtain on the different plantations. We had here some varieties which were complete failures at 400 feet elevation, that when planted at 1500 feet do much better than Caledonia. It is also best not to condemn a new variety too hastily from the results of a plant crop only. In sending out new seedlings all the seed possible is used, some of which is poor, the planting is not always done at the best season. These different things combine to give the cane a poor start. We therefore recommend that all new seedlings which are at all promising, be grown in small patches through several crops before final judgment be passed upon them.

J. A. V.

Rehabilitation.

By Donald S. Bowman,

Industrial Service Bureau, H. S. P. A.

Ewa plantation furnishes us with one of the best examples of what can be done in a sane, practical, economical manner to rehabilitate an old plantation village, creating thereby new conditions which are welcomed by the labor and approved by other parties interested in the well-being of the laborers.

A year ago the Filipino village at Ewa, although originally well planned

Fig. 1. Before remodelling. Two-family house with detached kitchen. Open fire cooking.

Fig. 2. After remodelling, same type house as No. 1. Additional windows. Illustrates method of attaching kitchen, which has a two-foot offset for concrete stove, sink with piped water, and drain board. Owing to the lines of the dwelling roof the kitchen shown was the most practical method of construction. Note hallway with cut-in steps. This provides ventilation, and gives space for working clothes, shoes, etc.

Fig. 3. Before improvement. Alley showing whitewashed detached kitchens, home-made fences, etc.

Fig. 4. After improvement. Same alley as No. 3. Detached kitchens, outhouses and fences removed, replaced by sanitary outbuildings, neatly stained, with yards uniformly fenced by plantation.

Fig. 5. After improvement. Sanitary outbuilding on alley line. Note attached kitchen and convenience of arrangement.

as to streets and size of yards, presented the usual features found in the older plantation settlements. The houses were of the two-family whitewashed type, with detached kitchens. The kitchens were the regular old-style, non-ventilated smoke-houses, open fires being the ordinary cooking arrangement. Wooden drains carried off the waste water. Although small concrete-floored wash-racks were provided, they served but a small portion of the population. The women

Fig. 6. After improvement. Remodelled dwellings, fenced-in, neat, attractive yards, trees and shrubs planted along streets.

Fig. 7. New plantation branch store and refreshment room. A great convenience for the community and a paying investment from all points of view.

usually did the family washing in the cookhouse, owing to the distance of the central washing floors.

The disposal of human waste was by the dry-earth system, the unsightly outhouses being situated on the alley lines. The village had no attractions, no electric lights, nor any of the features which go to make a village livable.

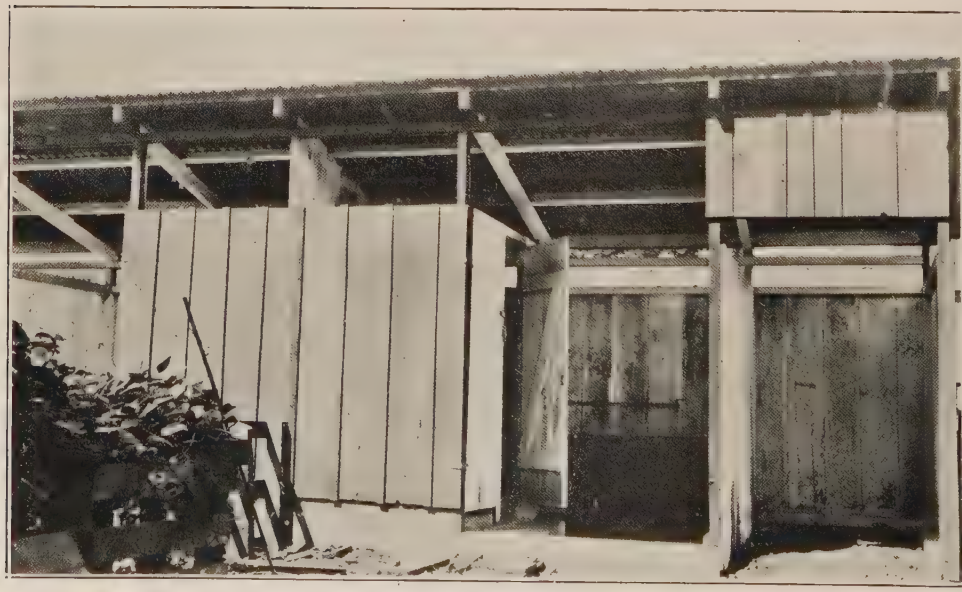


Fig. 8. New sanitary outbuilding, floor plans of which are shown in Figs. 9 and 10.

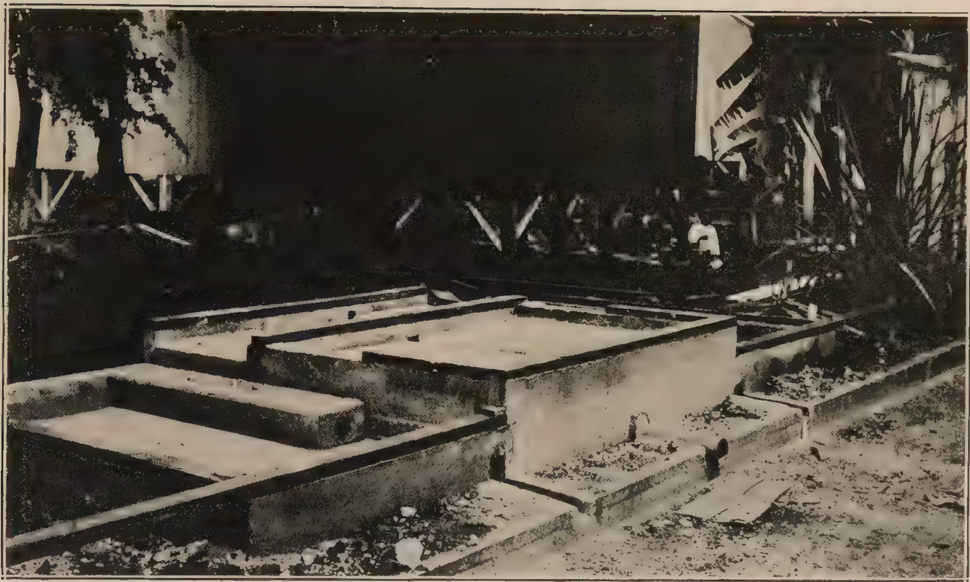


Fig. 9. Concrete foundation for sanitary outbuilding. This building provides Kentucky privy, wash room with redwood tubs, shower bath and wood shed.

At the request of the manager a survey of the village was made. This was followed by recommendations as to improvements, and these are now being carried out and will soon be completed. The rehabilitation and general improvement so far accomplished consists of the following items:

Remodelled Dwellings:

One hundred and twenty-five old two-family whitewashed dwellings converted into one-family, well-ventilated, stained exterior, attached kitchen cottages, equipped with electric lights, concrete stoves, kitchen sinks, running water, etc. These remade cottages are provided with sanitary outbuildings. Fifty-two more dwellings will undergo the same process.

Sanitary Outbuildings:

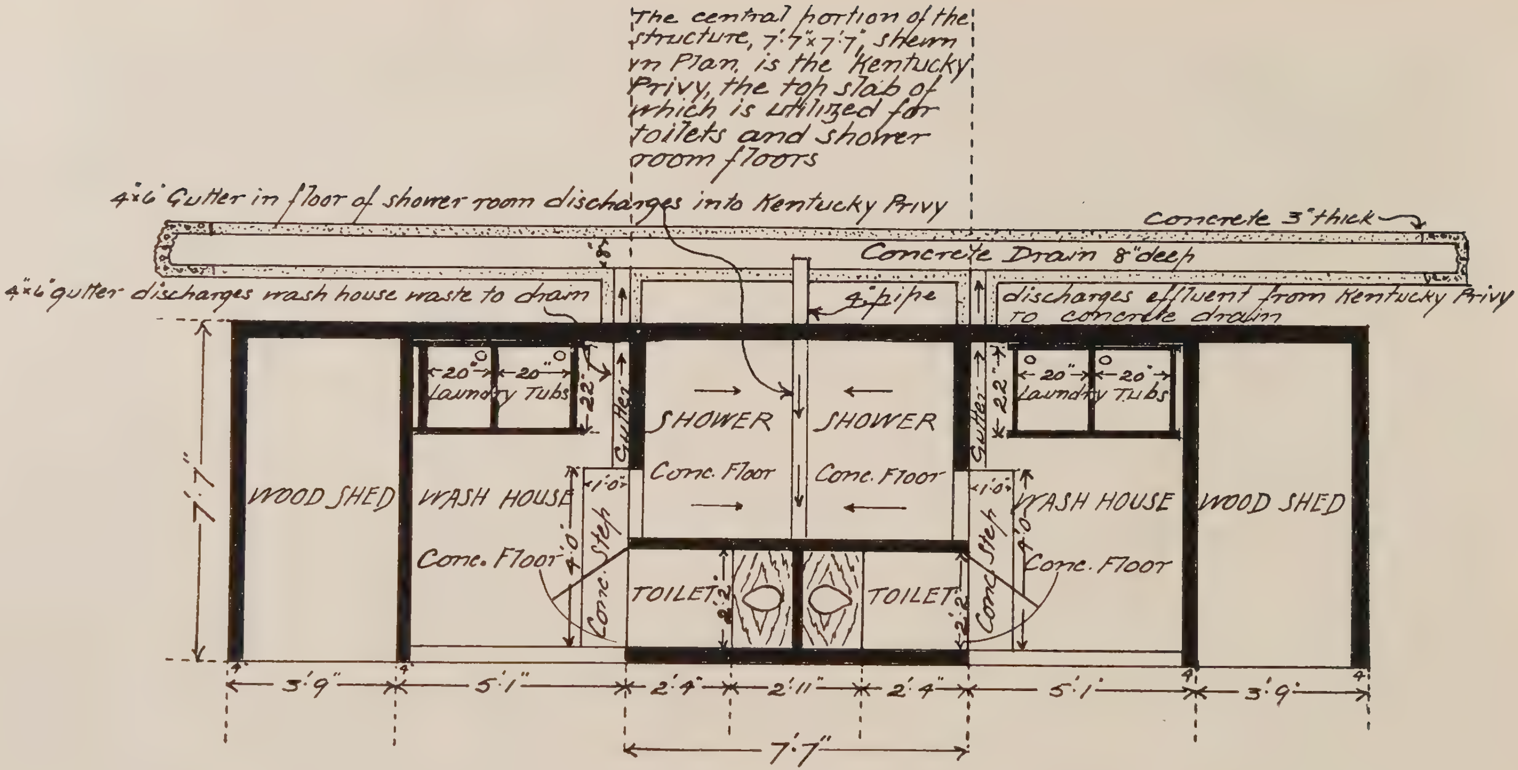
Each dwelling is provided with a sanitary outbuilding as shown in Fig. 8. The foundation of the building is concrete, the central portion being the top of the Kentucky privy. Space is provided for a washroom with stationary redwood tubs, a shower room, privy, and space for the storage of wood.

Club House:

An attractive club house has been provided, which is under the control of the Filipino Social Club. This club house is fitted with pool tables, tables for games, a reading room, player piano, phonograph, and other means of passing a pleasant hour. It is operated and maintained on a self-supporting basis, and there is a profit over and above expenses which is devoted to the purchase of club supplies and equipment. All receipts and expenditures are in the hands of the club, under the supervision of the industrial service worker.

Store:

For the convenience of the villagers a branch store was established, which has proven a great success.



PLAN OF

COMBINATION SANITARY OUTBUILDING

Fig. 10. Floor plan of sanitary outbuilding. Note the compact arrangement which makes use of the top slab of the Kentucky privy.

Electric Lights:

All buildings have been supplied with electric lights, and street lights are placed at regular intervals.

Bicycle Shop:

A bicycle shop is provided, where bicycles may be repaired, rented, etc.

Playground:

A space near the center of the village has been cleared for a playground, and apparatus provided.

Volleyball Courts:

Two volleyball courts are provided for the use of all who care to play.

Sanitation:

The improvements in sanitation have kept pace with the remodelling of the dwellings. Every dwelling is provided with a combination concrete wash, bath, and toilet building, in which space allows for the storage of wood, etc. The waste water and effluent from the Kentucky privies is carried off in concrete drains, which discharge into the irrigation ditches where a constant flow is maintained.

In addition to the above improvements the village has a church, Salvation Army hall, and a parsonage.

The rehabilitation of the village followed out the idea of unit housing, each dwelling being provided with a fenced-in yard and sanitary outbuildings.

The before and after photographs shown are more descriptive of the changes than any word picture we could draw. Work of this kind is most commendable, for there is no waste. At the same time the old buildings, by the expenditure of a very little money compared with the cost of a new dwelling, are made to serve for many years to come.

The transition is thus made from the old order to the new. This kind of work pays not only in prolonging the life of the old dwellings, but in creating more healthful conditions and converting a dull, listless village, with no home interest or community spirit, into a bright, happy settlement, with newly awakened interest in the plantation.

Forms of Nitrogen.

Waipio Experiment D, 1921 Crop.

This was an experiment planned to determine the comparative value of equal amounts of nitrogen when obtained from nitrate of soda, ammonium sulphate, equal amounts of ammonium sulphate and of nitrate of soda, and from dried blood. In addition to the above, complete fertilizer was used on a fifth series of plots. The cane was H 109, first ratoons, long, and 23 months old when harvested. At time of harvest, late June, this field had not been irrigated for slightly over 90 days. The quality ratio of the cane was 7.30.

The treatments applied to the different plots were as follows:

FERTILIZATION — POUNDS PER ACRE

Plots	No. of Plots	Fertilizer per Acre: September 1919	November 1919	February 1920	May 1920	Pounds: Nitrogen	P_2O_5	K_2O
A	15	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.	427 lbs. N. S.	250	....	....
B	15	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.	282 lbs. A. S.	250	....	....
C	14	174 lbs. N. S. 174 lbs. A. S.	174 lbs. N. S. 174 lbs. A. S.	174 lbs. N. S. 174 lbs. A. S.	210 lbs. N. S. 140 lbs. A. S.	250	....	....
D	14	1030 lbs. Blood	....	1030 lbs. Blood	....	250	....	....
E	14	305 lbs. A. S. 632 lbs. A. P. 164 lbs. S. P.	305 lbs. A. S.	305 lbs. A. S.	282 lbs. A. S.	250	100	80

The results of the harvest are given below:

Treatment	Tons per Acre: Cane	Sugar
Nitrate of Soda..........................	109.0	14.93
Ammonium Sulphate	107.3	14.70
Nitrate of Soda and Ammonium Sulphate ..	107.0	14.66
Dried Blood	105.8	14.50
Complete fertilizer	110.6	15.15

The yields obtained from the varied treatments differ but little from each other. Complete fertilizer produced slightly more cane and sugar than did any of the other treatments, but the gains were not large enough to pay for the extra cost when compared with the nitrate of soda plots. The best financial returns were obtained from the nitrate of soda plots. Dried blood gave the lowest yields at the highest cost per unit of nitrogen.

DETAILS OF THE EXPERIMENT.

Fertilizer Experiment — Forms of Nitrogen.

Object:

1. To compare the relative value of the following forms: Nitrate of soda, ammonium sulphate, mixture of ½ nitrate of soda and ½ ammonium sulphate, and organic nitrogen (dried blood).
2. To compare complete fertilizer (nitrogen, phosphoric acid, and potash) with nitrogen alone.

Location:

Waipio Substation, Section 7.

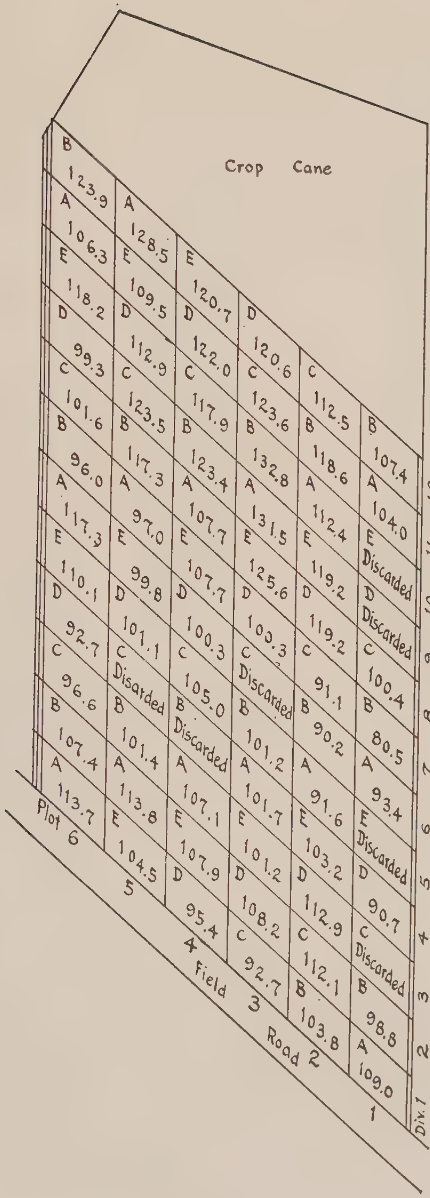
Crop:

H 109 First Ratoons, long.

FORMS OF NITROGEN

Waipio Substation Exp. D, 1921 Crop

Section 7.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Yields Per Acre Sugar
A	15	1616# Nitrate of Soda	109.00	14.93
B	15	1220# Ammonia Sulphate	107.32	14.70
C	14	696# Nitrate of Soda 696# Ammonia Sulphate	107.01	14.66
D	14	2060# Dried Blood	105.81	14.50
E	14	1616# Ammonia Sulphate 632# Acid Phosphate 164# Sulphate of Potash	110.62	15.15

Layout:

Number of plots = 72.
Size of plots = 1/30 acre (net).
Eight lines per plot.

Plan:

Fertilization in pounds fertilizer per acre.

Plots	No. of Plots	First Season		Second Season	
		Aug. 1919	Nov. 1919	Feb. 1920	May 1920
A	15	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.
B	15	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.
C	14	367 lbs. ½ A. S., ½ N. S.	367 lbs. ½ A. S., ½ N. S.	367 lbs. ½ A. S., ½ N. S.	367 lbs. ½ A. S., ½ N. S.
D	14	1030 lbs. Dried Blood	....	1030 lbs. Dried Blood	....
E	14	305 lbs. A. S. 632 lbs. P_2O_5 164 lbs. K_2O	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.

J. A. V.

Amount of Fertilizer and Number of Applications.

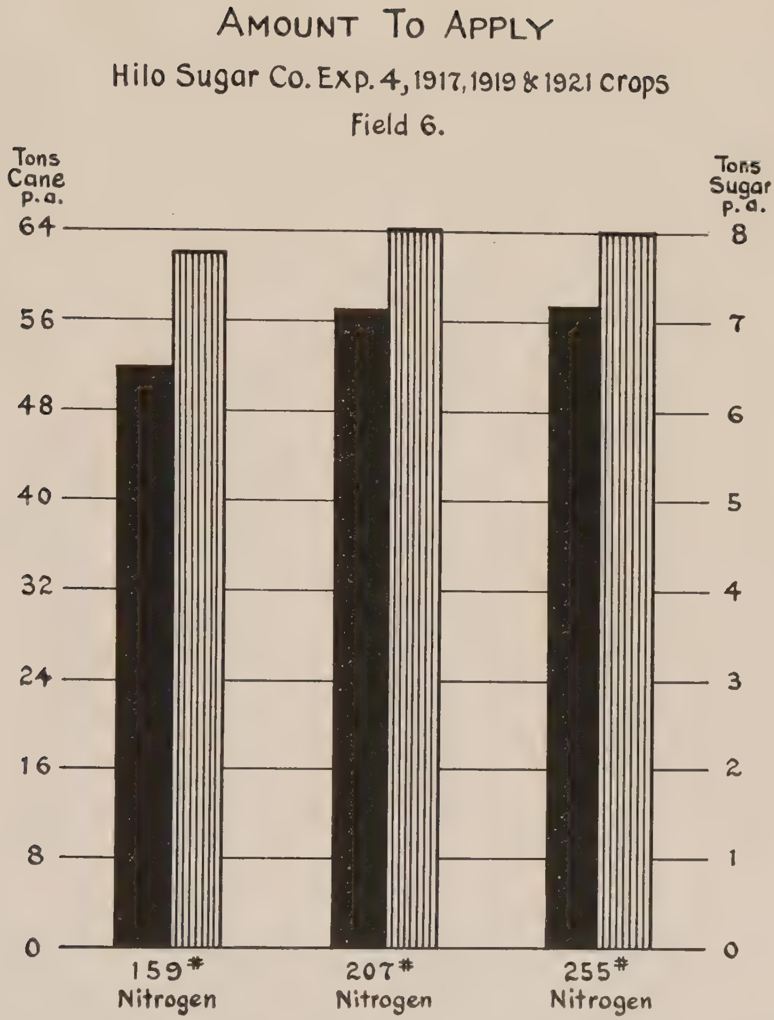
Hilo Sugar Company Experiments 4 and 5, 1917, 1919, and 1921 Crops.[1]

These were experiments planned to determine the most profitable amount of fertilizer to use during the second season, and the best number of doses in which to apply it. The tests were carried out entirely on ratoons, the 1917 crop being first ratoons.

During the first season all plots received uniform fertilization, the amount used being according to plantation practice, and consisted of nitrate of soda and mixed fertilizer. During the second season varying amounts of nitrogen were used and applied in one, two and three doses.

The treatments given and the results obtained for the different crops are summarized in the following tables:

[1] See Planters' Record, Vol. XVII, p. 97; Vol. XXI, p. 270.



HILO EXPERIMENT NO. 4—1917 CROP.

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
935 lbs. Complete Fert [2]	375 lbs. Spring Dressing [3]	146	57.0	8.15
935 lbs. Complete Fert.	750 lbs. Spring Dressing	198.5	57.9	8.20
935 lbs. Complete Fert.	1125 lbs. Spring Dressing	251	58.6	8.22

[2] Complete fertilizer = 10% N., 7% P_2O_5, 4½% K_2O.

[3] Spring dressing = 14% N., 4% P_2O_5.

HILO EXPERIMENT NO. 4—1919 CROP

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
250 lbs. N. S., 1000 lbs. B 5[1]	300 lbs. C 1[2]	202	61.2	8.76
250 lbs. N. S., 1000 lbs. B 5	600 lbs. C 1	255	61.9	8.83
250 lbs. N. S., 1000 lbs. B 5	900 lbs. C 1	308	62.2	8.86

[1] B 5 = 11% N., 8% P_2O_5.
[2] C 1 = 17.75% N.

HILO EXPERIMENT NO. 4—1921 CROP.

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
250 lbs. C 2[1], 500 lbs. B 6[2]	339 lbs. B 5[3]	130	47.1	6.37
250 lbs. C 2, 500 lbs. B 6	677 lbs. B 5	168	51.4	7.07
250 lbs. C 2, 500 lbs. B 6	1016 lbs. B 5	206	51.7	6.94

[1] C 2 = 15% N., 9.5% K_2O.
[2] B 6 = 11% N., 6% P_2O_5.
[3] B 5 = Same as previous.

HILO EXPERIMENT NO. 4—AVERAGE OF THREE CROPS (1917, 1919, and 1921).

Amount to Apply

Average Pounds of Nitrogen per Acre	Tons per Acre	
	Cane	Sugar
159 Pounds	51.8	7.76
207 Pounds	57.1	8.03
255 Pounds	57.5	8.01

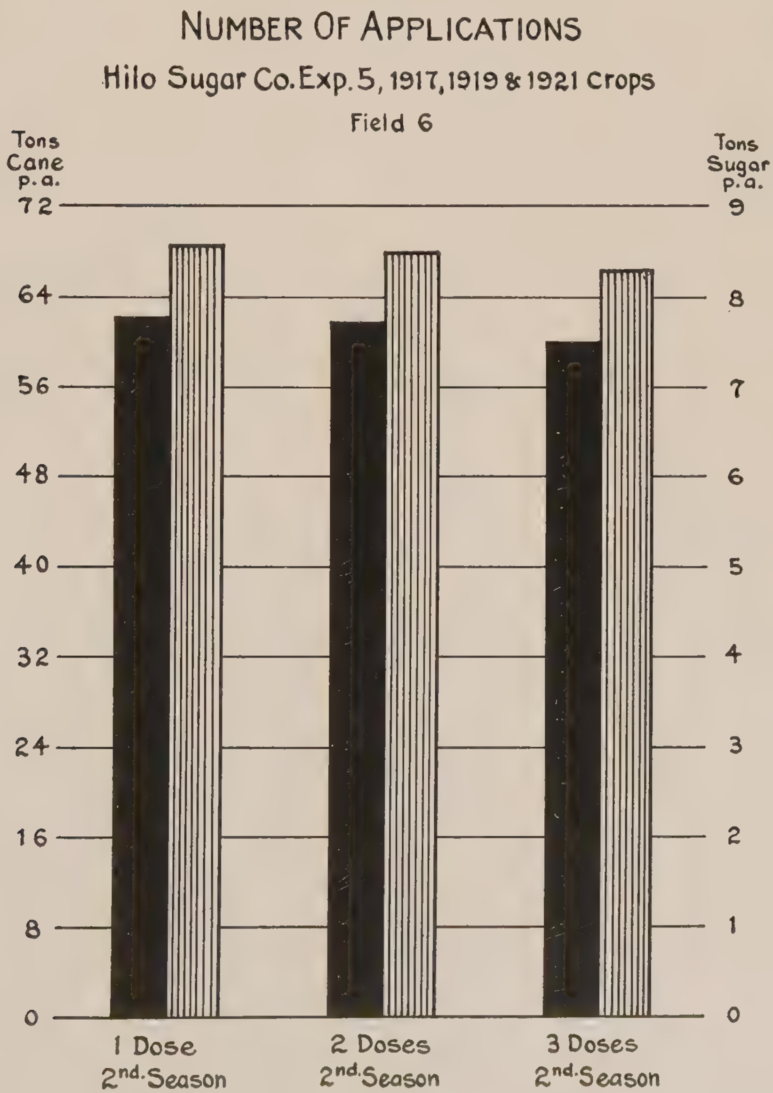
HILO EXPERIMENT NO. 5—1917 CROP.

Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Three applications	One application	66.7	9.42
Three applications	Two applications	64.8	9.11
Three applications	Three applications	61.3	8.62

HILO EXPERIMENT NO. 5—1919 CROP.
Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Three applications	One application	64.7	8.73
Three applications	Two applications	65.6	8.88
Three applications	Three applications	64.2	8.66



HILO EXPERIMENT NO. 5 — 1921 CROP.
Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Two applications	One application	55.6	7.61
Two applications	Two applications	55.1	7.57
Two applications	Three applications	54.8	7.63

HILO EXPERIMENT NO. 5 — AVERAGE OF THREE CROPS (1917, 1919, and 1921).

Number of Applications	Tons per Acre	
	Cane	Sugar
One second season	62.3	8.59
Two second season	61.8	8.52
Three second season	60.1	8.30

In experiment No. 4, we find, as the result of three crops, that the profitable limit of nitrogen application was reached with about 200 pounds of nitrogen per acre. In this connection it is well to call attention to the fact that on account of war conditions very little potash was used during the time of these experiments. The soils in the Hilo district are responding in a marked manner to potash applications. It is possible that with liberal potash applications the cane would be able to utilize larger amounts of nitrogen. Experiments are under way to determine this point.

In regard to the results from the number of applications, we find that the returns are as good or better when the fertilizer is applied in one dose during the second season, rather than in more. Results of a similar nature are being obtained right along in other experiments being harvested on the different islands. With present labor conditions, when it is so difficult to get work done properly, we believe all fertilizing should be done in not more than three applications per two-year crop. Two doses only would not be extreme. At the present time it is difficult to get the fields properly cleaned before fertilizing. Cutting down in the number of applications will help there. It is also well to bear in mind that late fertilization during the second season lowers the quality of the juices, more particularly that from the fields first harvested.

DETAILS OF EXPERIMENTS.

Hilo Sugar Company Experiment No. 4 — 1921 Crop.

Second Season Fertilization — Amount to Apply.

Object:

To compare different amounts of fertilizer when applied in a given number of doses.

Location:

Hilo Sugar Company, field 6, plots 46–90 incl., adjoining Experiment No. 5 on the Hilo side.

HILO SUGAR CO. EXP. 4 & 5, 1921 CROP

Experiment 4. Amount To Apply.
Experiment 5. Number Of Applications.

Field 6.

Exp. 4.	Exp. 5.
46 A 47.03	1 A Discarded
47 D 57.44	2 B 55.23
48 G 57.57	3 C 47.64
49 A 42.92	4 A 49.46
50 D 49.21	5 B 48.28
51 G 51.32	6 C 59.52
52 A 45.61	7 A 57.42
53 D 49.50	8 B 55.14
54 G	9 C 54.33
55 A	10 A 52.72
56 D	11 B 50.70
57 G	12 C 50.52
58 A	13 A 50.91
59 D	14 B 56.63
60 G Discarded	15 C 54.84
61 B	16 D 57.88
62 E	17 E 54.24
63 H	18 F 53.11
64 B	19 D 54.57
65 E	20 E 48.97
66 H	21 F 49.68
67 B	22 D 49.85
68 E	23 E 55.32
69 H 48.45	24 F 54.06
70 B 46.66	25 D 57.80
71 E 56.70	26 E 56.79
72 H 56.04	27 F 57.44
73 B 56.09	28 D 63.86
74 E 59.61	29 E 62.64
75 H 45.88	30 F 53.08
76 C 45.51	31 G 59.04
77 F 49.88	32 H 62.43
78 I 52.31	33 I 63.74
79 C 55.90	34 G 66.18
80 F 58.17	35 H 63.27
81 I 59.67	36 I 59.80
82 C 44.82	37 G 54.45
83 F 47.26	38 H 49.22
84 I 45.99	39 I 56.08
85 C 42.89	40 G 54.04
86 F 48.97	41 H 55.46
87 I 51.03	42 I 56.10
88 C 43.31	43 G 52.93
89 F 47.12	44 H 52.04
90 I 49.20	45 I 51.48
← 140.7′ →	← 140.7′ →

1392′

Road

Exp. 4. Summary of Results

Amount To Apply	Tons Per Acre Cane	Tons Per Acre Sugar
129.5 Pounds of Nitrogen	47.1	6.37
168 " " "	51.4	7.07
205.5 " " "	51.7	6.94

Exp. 5. Summary of Results

Number Of Applications	Tons Per Acre Cane	Tons Per Acre Sugar
2 First Season, 1 Second Season	55.6	7.61
2 " " 2 " "	55.1	7.57
2 " " 3 " "	54.8	7.63

Crop:

Yellow Caledonia, Third Ratoons.

Layout:

Number of plots = 45. Size of plots = 1/10 acre, consisting of 6 furrows, 5.16′ wide by 140.7′ long.

Plan:

First Season Fertilization — Uniform

Plots	No. of Plots	Lbs. C 2 per acre Sept., 1919	Lbs. B-6 per acre Dec., 1919 *		Total Nitrogen
All	45	250	500		93.75
		Second Season Fertilization			
Plot	No. of Plots	Lbs. B-5 per acre Mar. 15, 1920	May 15, 1920	July 1920	
A	5	338.7	0	0	
B	5	169.4	169.4	0	37.25
C	5	112.9	112.9	112.9	
D	5	677.4	0	0	
E	5	338.7	338.7	0	75.51
F	5	225.8	225.8	225.8	
G	5	1016.1	0	0	
H	5	508.0	508.1	0	112.87
I	5	338.7	338.7	338.7	

* Depending on growth of cane — otherwise 500 pounds in February.

Experiment planned by L. D. Larsen.
Experiment laid out by L. D. Larsen and J. S. B. Pratt, Jr.

Hilo Sugar Company Experiment No. 5 — 1921 Crop.
Fertilization — Number of Applications.

Object:

To compare different numbers of applications for varying amounts of fertilizer.

Location:

Hilo Sugar Company, field 6, plots 1–45 incl., on the Hilo side of the narrow field road that extends makai from the top of the field.

Crop:

Yellow Caledonia, Third Ratoons.

Layout:

Number of plots = 45. Size of plots = 1/10 acre, consisting of 6 lines, 5.16′ wide and 140.7′ long.

Plan:

First Season Fertilization — Uniform

Plots	No. of Plots	Lbs. C-2 per acre Sept., 1919	1 Lb. B-6 per acre Dec., 1919 *; Feb., 1920		Total Nitrogen	
All	45	250	250	250	93.75	
	Second Season Fertilization					
No. of Applications	Plots	Lbs. B-5 per acre				
1	A	338.7			37.26	Mar. 15, 1920
	D	677.4			75.51	
	G	1016.1			112.87	
2	B	338.7			37.27	Mar. 15, 1920 May 15, 1920
	E	677.4			75.51	
	H	1016.1			112.87	
3	C	338.7			37.27	Mar. 15, 1920 May 15, 1920 July 15, 1920
	F	677.4			75.51	
	I	1016.1			112.87	

* Depending on growth of cane — otherwise 500 pounds in February.

Experiment planned in 1916, by L. D. Larsen.
Experiment laid out in 1916, by L. D. Larsen and J. S. B. Pratt, Jr.

J. A. V.

Amount of Fertilizer, Time of Application, and Forms of Nitrogen.

MAKEE SUGAR COMPANY, EXPERIMENTS 1, 2, AND 3.

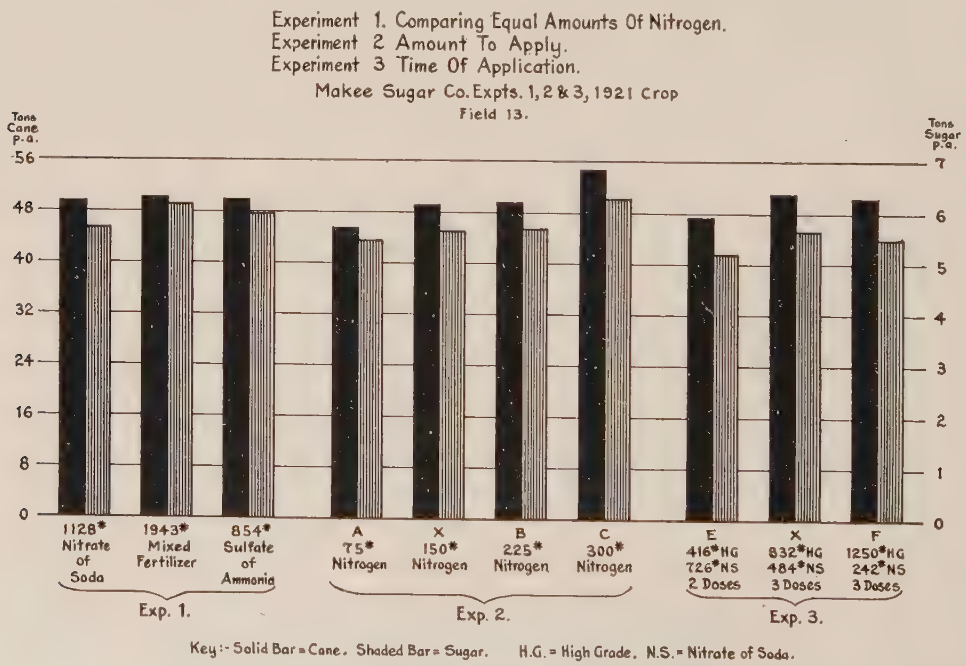
These experiments have now been carried on for two crops, one plant and one ratoon. They are laid out in Field 13. The field is irrigated and planted to Yellow Caledonia cane.

Makee Sugar Company, Experiment No. 1.

This experiment compares equal amounts of nitrogen from nitrate of soda, ammonium sulphate, and from mixed fertilizer containing 9 per cent nitrogen and 7 per cent phosphoric acid.

The treatments to the different plots are given as follows:

No. of Plots	Fertilizer—Pounds per Acre	Total Pounds Nitrogen	Total Pounds P_2O_5
10	1128 lbs. nitrate of soda, in 3 doses...............	175	0
8	1943 lbs. mixed fertilizer, in 3 doses..............	175	135
10	854 lbs. ammonium sulphate, in 3 doses...........	175	0



The results obtained in the two harvests are given in the following table:

Treatment	Tons Cane per Acre		
	1919 Crop	1921 Crop	Average
Nitrate of Soda	63.1	49.6	56.3
Mixed Fertilizer	64.3	50.2	57.2
Ammonium Sulphate	62.8	49.8	56.3

The mixed fertilizer plots, in addition to the nitrogen, received 135 pounds of P_2O_5 (equal to 844 pounds of acid phosphate) per acre, yet these plots produced but very little more per acre than the plots receiving no phosphoric acid, thus indicating the need of very little phosphoric acid at the present time.

Makee Sugar Company, Experiment No. 2.

This experiment was to determine the economic limit in nitrogen applications. During the first growing season mixed fertilizer was used, containing 9 per cent nitrogen and 7 per cent phosphoric acid; during the second season nitrate of soda was applied. On account of war conditions no potash was used.

The amounts of fertilizer used on the different plots are tabulated below:

No. of Plots	Fertilizer—Pounds per Acre	Nitrogen	P_2O_5
11	243 lbs. mixed fertilizer, 134 lbs. Nit. Soda	75	17
12	486 " " " 269 " " "	150	34
11	729 " " " 403 " " "	225	51
11	972 " " " 537 " " "	300	68

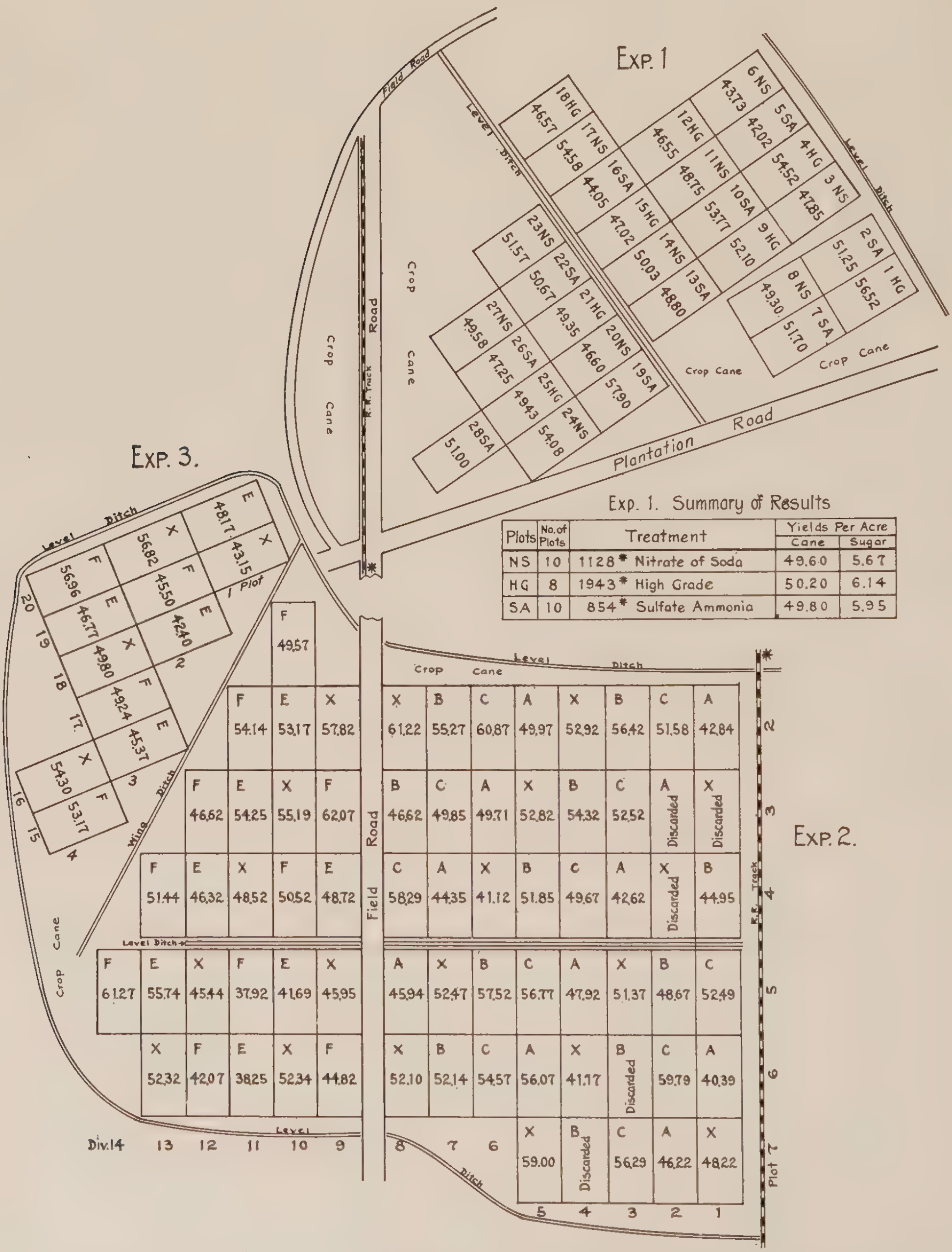
The results for each crop and the average are given as follows:

Pounds of Nitrogen	Tons of Cane per Acre		
	1919 Crop	1921 Crop	Average
75	62.7	45.5	53.6
150	67.0	49.2	58.1
225	66.6	49.6	58.1
300	67.5	54.8	61.1

In the plant crop the profitable limit in nitrogen application was reached with 150 pounds per acre. The ratoons seem to require more, as the "300 pounds of nitrogen" plots gave distinctly more sugar per acre. Before arriving at definite conclusions we deem it best to repeat this test on one or two more ratoon crops.

Experiment 1. Comparing Equal Amounts Of Nitrogen.
Experiment 2. Amount To Apply.
Experiment 3. Time Of Application.

Makee Sugar Co. Expts. 1, 2 & 3, 1921 Crop
Field 13.



Exp. 1. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
NS	10	1128* Nitrate of Soda	49.60	5.67
HG	8	1943* High Grade	50.20	6.14
SA	10	854* Sulfate Ammonia	49.80	5.95

Exp. 3. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
E	11	2 Doses, 416* H.G., 726* N.S.	47.40	5.22
X	11	3 Doses, 832* H.G., 484* N.S.	51.10	5.67
F	14	3 Doses, 1250* H.G., 242* N.S.	50.40	5.52

H.G. = High Grade. N.S. = Nitrate of Soda.

Exp. 2. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
A	11	75* Nitrogen	45.50	5.44
X	12	150* Nitrogen	49.20	5.65
B	11	225* Nitrogen	49.60	5.68
C	11	300* Nitrogen	54.80	6.28

Makee Sugar Company, Experiment No. 3.

In this experiment we attempted to determine what proportion of fertilizer to add each season. The cane was Yellow Caledonia plant and first ratoon, two crops having been harvested.

The fertilizer applications are shown in the following tables for the two crops:

Plots	No. of Plots	Division of Fertilizer						
		1919 Crop—Plant				1921 Crop—1st Ratoon		
		1st Season		2nd Season		1st Season		2nd Season
E	12	1/4	0	3/8	3/8	1/4	0	3/4
X	11	1/4	1/4	1/4	1/4	1/4	1/4	1/2
F	12	3/8	3/8	1/4	0	3/8	3/8	1/4

The yields obtained from the two crops are as follows:

Amt. Fert. per Season		Total Nitrogen	Tons Cane per Acre		
1st Season	2nd Season		1919 Crop	1921 Crop	Average
1/4	3/4	150 lbs.	66.5	47.4	56.9
1/2	1/2	150 lbs.	65.6	51.1	58.3
3/4	1/4	150 lbs.	64.0	50.4	57.1

It does not seem to make a very great deal of difference as to how the fertilizer is divided, yet the tendency is very definitely in favor of applying half or more of the fertilizer during the first growing season. The ratoon crop, which responded more to the fertilizer than did the plant crop, shows this tendency rather strongly.

DETAILS OF EXPERIMENTS.

MAKEE SUGAR COMPANY, EXPERIMENT NO. 1, 1921 CROP.

Forms of Nitrogen.

Object:

To compare nitrogen in the form of: 1, nitrate of soda; 2, sulphate of ammonia; and 3, mixture of nitrate, sulphate, and organic nitrogen.

Location:

Field 13, Makee Sugar Company.

Crop:

Yellow Caledonia, first ratoons, long.

Layout:

Number of plots = 28.

Size of plots = 1/10 acre (90′x 48.4′), consisting of 20 lines, each 4.5′x 48.4′.

Plan:

Fertilization in pounds nitrogen per acre:

Plot	No. of Plots	Plot No.	Fertilizer	Pounds Nitrogen per Acre			Lbs. N. Total
				Aug. 15, 1919	Nov. 15, 1919	Feb. 15, 1920	
NS	10	3, 6, 8, 11, 14, 17, 20, 23, 24, 27....	Nit. Soda	50	50	75	175
HG	8	1, 4, 9, 12, 15, 18, 20, 25..........	High Grade	50	50	75	175
SA	10	2, 5, 7, 10, 13, 16, 19, 22, 26, 28....	Sul. Ammo.	50	50	75	175

NS = 15.5% nitrogen.

HG = 9% nitrogen, (3% sulphate, 3% nitrogen, 3% organic), 7% P_2O_5 (4% acid phosphate, 3% bone).

SA = 20.5% nitrogen.

Makee Sugar Company, Experiment No. 2, 1921 Crop.

Fertilizer Experiment — Amount to Apply.

Object:

To determine the most profitable amount of nitrogen to apply, i. e., 75, 150, 225, or 300 pounds per acre.

Location:

Field 13.

Crop:

Yellow Caledonia, first ratoons.

Layout:

Number of plots = 45.

Size of plots = 1/10 acre (48.4′x 90′), composed of 20 straight rows, each 4½′x 48.4′.

Plan:

Fertilization in pounds nitrogen per acre:

Plots	No. of Plots	August, 1919	Nov., 1919	Feb., 1920	Total
A	11	25	25	25	75
X	12	50	50	50	150
B	11	75	75	75	225
C	11	100	100	100	300

Nitrogen to be applied first season in form of plantation High Grade of following composition:

H. G. = 9% N. (3% nitrate, 3% sulfate, 3% organic), 7% $P_2 O_5$ (4% water sol., 3% bonemeal).

N. S. = Nitrate of soda, 15.5% nitrogen.

Second season nitrogen to be applied as nitrate of soda.

Makee Sugar Company, Experiment No. 3, 1921 Crop.

Fertilizer Experiment — Time of Application.

Object:

To determine what proportion of the fertilizer to apply each season.

Location:

Field 13.

Crop:

Yellow Caledonia, first ratoons.

Layout:

Number of plots = 36.

Size of plots = 1/10 acre (48.4'x 90'); 24 plots composed of 20 straight lines, each 4½'x 48.4'. The other 13 plots have irregular lines.

Plan:

Proportion of fertilizer applied at different times of year.

Plot	No. of Plots	First Season		Second Season	Total Lbs. N. per Acre
		Aug., '19	Nov., '19	Feb., '20	
E	11	1/4	0	3/4	150
X	11	1/4	1/4	1/2	150
F	14	3/8	3/8	1/4	150

Total amount of nitrogen to be applied = 150 pounds; first season fertilization to be with H. G. and second season with nitrate of soda.

H. G. = 9% N. (3% nitrate, 3% sulfate, 3% organic), 7% P_2O_5 (4% water sol., 3% bonemeal).

J. A. V.

Furnace Design and Boiler Efficiency.*

By D. S. Jacobus.

To approach perfection from a thermal viewpoint, a boiler and superheater, including its economizer and air heater, if used, should absorb a maximum amount of heat with a minimum draft drop. There are commercial elements entering into the problem that limit the application of this principle, and so many variables that each case must be considered by itself in order to arrive at the best arrangement. A relatively large amount of boiler heating surface, with large flow spaces for the gases, if properly insulated to prevent undue radiation, would more nearly meet the requirements of absorbing a maximum amount of heat from a given weight of fuel burned with a minimum draft drop than a smaller amount of surface, although the latter would in most cases be preferable from a commercial point of view. Adding an economizer will ordinarily add to the thermal efficiency.

* Abstract of a paper delivered before the Cleveland Engineering Society and local section American Society of Mechanical Engineers at Cleveland, and the Akron section at Akron, Ohio, April 26 and 27, 1921.

Determining Whether an Economizer Will Pay.

To determine whether it will pay to use economizers in a new plant, the problem should not be approached by comparing the efficiency of a boiler with that of the same boiler with an economizer added to it. The proper way is to compare the results to be expected from boilers best suited for the service without the addition of economizers to those to be expected for the best combination of boilers and economizers.

It will sometimes be found for exceptional load conditions that a larger boiler properly designed and baffled will give better commercial returns, all features considered, than a smaller boiler with an economizer — or, for that matter, for any boiler that can be selected with an economizer.

For peak load service it does not usually pay to install economizers on all boilers. A good arrangement may be secured for some classes of service by adding economizers to, say, one-third of the boilers, operating them at a more nearly uniform load than the rest and cutting in those that have no economizers during the peak load periods.

Another case where it does not pay to apply economizers is where boilers are used for stand-by service. The cost of fuel is a governing factor, and because of the increase in fuel costs during the last few years we are approaching more closely to European practice in the number of boilers so fitted.

In designing a boiler for use without an economizer, additional efficiency may be secured by adding to its height. Increasing it from, say, 14 to 20 tubes high will result in a considerable increase in efficiency without a corresponding increase in the draft loss, as much of the draft loss in boilers comes through the turns made by the gases in passing over the baffles.

To avoid exterior corrosion through the condensation of moisture from the flue gases, the temperature of the feed water to the economizers must be kept above a temperature of about 120° F., and for most work we recommend 140° F., as this allows for some leeway in case the water is fed intermittently.

It is becoming more general practice to use an individual economizer on each boiler and not to install connections for by-passing the gases around the economizer. A by-pass connection as a rule allows some leakage of the hot gases and causes a continual loss of efficiency and its omission is also advantageous in simplifying operation and lessening the chance of trouble with the economizers.

Danger of Overheating Brickwork.

For securing the highest efficiency the furnace temperature should be the maximum that can be maintained, and combustion should be completed within the furnace chamber. The furnace brickwork employed today will fail if saturated with heat at the full temperature that is available with many classes of fuel. In furnace design, therefore, some efficiency must be sacrificed in most cases in order to maintain the furnace brickwork and keep the cost of repairs within a reasonable figure.

Where furnaces are operated under a suction that causes the cool air to be drawn inward through the brickwork, there is a cooling effect that serves

to prevent overheating, whereas if they are operated under a pressure, there is a tendency for the hot gases to leak outward and overheat the brickwork.

Brickwork will fail by plastic deformation before it reaches the melting point. The greater the load carried by the brick, the more likely it is to fail. Fireclay brick of the best quality ordinarily obtainable begins to show plastic deformation under a load of 20 pounds per square inch at from 2200° to 2400° F. Reduction to a load of 10 pounds per square inch will increase the permissible temperatures about 200° F. As furnace temperatures considerably higher than this exist with certain grades of fuel and stoker practice, say 2700° to 3000° F. as a limit, it is apparent that the necessity of maintaining the brickwork below the temperature of the furnace is a vital one. First-class clay bricks have a fusion point slightly above 3100° F. and yield through plastic deformation long before they fuse.

In ordinary furnace design the walls and arches are heated on one side only in order that the brickwork may be maintained at a lower temperature than that of the furnace. A wall of a given thickness that would give good service as a battery wall might fail under the same fuel and combustion if used as a supporting wall between two combustion arches, as the heat would not be conducted away from the wall to the extent that it would when used as a battery wall, and the reflected heat from the arches would also increase its temperature. Such a supporting wall should be used between combustion arches only in cases where a low grade of fuel is burned, which does not result in high temperatures, or it should be ventilated.

To consume the combustible gases within the furnace chamber there should be a proper length of flame travel before the gases strike the tubes and a sufficient furnace volume. Furnace volume and length of flame travel are not, however, the only elements that must be considered in designing an efficient furnace, as there must be a mingling action within the furnace to cause any unconsumed conbustible gases to reach the excess air.

Effect of Radiant Heat Absorption.

The effect of the absorption of radiant heat on the boiler tubes should be considered in designing a furnace. With certain fuels, such as blast furnace gas, wet wood or bagasse, where the highest attainable temperature can be carried by the brickwork, it is best to absorb but little radiant heat in order to maintain a high furnace temperature and thereby increase the efficiency of combustion. With the stronger fuels it is necessary to absorb a considerable amount of the radiant heat in order to prevent the collapse of the brickwork or an undue amount of deterioration.

Exposing more or less of the boiler surface to the direct radiant heat of the fire has a comparatively small influence on the efficiency, as any increase in the heat absorbed through direct radiation is counterbalanced to an extent by the diminution of the amount of heat absorbed through conduction. Ordinarily, the higher the furnace temperature, the higher the efficiency. Higher furnace temperatures, however, lead to increased cost of brickwork maintenance, especially when the boilers are operated at high ratings, and for a strong

fuel it usually pays to expose a considerable proportion of the heating surface of the boiler to the direct action of the radiant heat.

Rating for Economical Operation of Boilers.

The economical rating is naturally influenced by the presence or absence of economizers and the service to which the boilers are put. Where there are short peak-load periods, the greatest commercial economy is usually secured by operating the boilers to as high a capacity as can be secured during these periods.

The general practice in this country is to drive boilers at a higher rating than is done in European practice, and the stress of war conditions has undoubtedly led to a number of plants being run beyond the point of the best commercial efficiency.

A furnace for operating at high capacities should be larger than for operating at low capacities; a furnace to give economical results at high ratings therefore involves special problems in caring for the expansion of the brickwork and especial care in the construction of buckstays for holding the brickwork in alinement. The general tendency in large furnace walls which are highly heated is to bulge inward toward the fire, and unless means are provided to prevent this they may collapse.

In our present practice we use bonding tile, which is held by cast iron bulb pieces attached to the buckstays in such a way that the wall can expand in any direction in a generally vertical plane, whereas it is prevented from either bulging inward or outward. Another means that may be employed to prevent the walls bulging inward toward the fire is to build them with a camber having a vertical axis—that is, curved slightly, with the concave side next the furnace.

Trouble From Slag Adhering to Tubes.

In operating at higher ratings, difficulties are encountered with some grades of fuel through slag adhering to the boiler tubes and restricting or closing up the passageways for the flow of the gases. The difficulty through slag can be reduced by providing a relatively large area for the flow of gases on entering the spaces between the tubes and by furnishing access doors through which the slag can be detached from the tubes. An air lance, which is used both for cooling the slag and as a rod for striking it to remove any portion that may adhere to the tubes, forms an efficient tool for use in connection with the access doors.

With certain grades of coal there will be some accumulation of slag on the boiler tubes with the stokers most carefully operated, and it is advantageous in such cases to provide access doors for removing the slag.

Reducing Clinker Trouble.

Trouble from clinker at the sides and front walls of the furnace where underfeed stokers are used is often reduced by admitting air through a number of openings in the walls at the sides of the fuel bed. The air flows in a layer against the inner face of the wall and prevents the clinker adhering to them. It also serves to partly cool the wall and reduce its erosion.

It can readily be seen that furnace design and boiler design must be co-

ordinated in order to secure the best results. It is impossible to separate boiler efficiency from the efficiency of the stoker and furnace. Many have worked on this problem, and the ground has probably been gone over more thoroughly than any other feature of boiler testing codes. The result has always been in reaching the conclusion that it is impossible to separate the furnace and stoker efficiency from the combined efficiency of the boiler, stoker, and furnace in such a way that the result may not be misleading. W. E. S.

You, Mr. Watertender.*

The following was recently sent out by W. E. Thomson, steam-plant engineer of the Southern California Edison Co., to all watertenders of the company as an appeal to "sell them their jobs." It is well worth the attention of all boiler-plant employers.

Do you, Mr. Watertender, realize that you occupy an important position? You are largely responsible for the lives and safety of others as well as yourself. You have almost as much to do with the efficiency made by your shift as has the fireman. You are the one to see that the water is heated as hot as possible before it leaves the heater so that you gain by using all of the exhaust steam. Heating the water hot before it enters the boiler helps the boiler. It does not have to put so much heat into each pound of water, hence you increase the amount of steam the boiler can make. This increased capacity, especially over the peak load, enables your station to carry more kilowatts. Every eleven degrees you can heat the feed water by using exhaust steam means a saving of one per cent in the amount of fuel oil used on your shift, and almost one per cent gain in boiler capacity.

Watch the Water Level.

By watching the water level in the boiler, you keep the boiler from going dry, perhaps exploding. At one of our plants someone did not watch the water level. The water in a boiler was allowed to get low—way out of sight in the glass. A tube burst. Luckily, no one was injured, as the force of the explosion happened to be sideways into other tubes. But the whole front bank of tubes had to be renewed. The brickwork had to be repaired. The total cost was over $1100, besides the loss from having the boiler out of service.

It is you, Mr. Watertender, who must watch to see that the water does not get too high in the glass. If it does get too high, the water will go over into the steam main. The temperature of the steam is lowered. More steam is required to carry the same load. More oil has to be used to make the steam. Hence your shift efficiency suffers. But this is not all. If enough water goes over, it is likely to wreck some machine. An instance of this happened not long ago. An exciter was wrecked. Fortunately, no one was hurt, but the repairs cost over $500, and for some time, until the parts were received from the fac-

* From "Power."

tory, the other exciters were overloaded and the plant in danger of shutting down any minute. This water, going over into the turbines, corrodes and scales the parts, causing a loss not only to your shift efficiency, but to everybody else's until the machine can be taken out and overhauled.

Feed the Water Gradually.

It is you, Mr. Watertender, who can help your fireman and your shift efficiency by feeding the water into the boilers gradually, not have a valve half open one minute and closed the next, but set the valves so that the water goes into the boiler just as fast as the steam-flow meter shows it is going out. It has been shown by tests that a swinging load will cause a loss of over 5 per cent, and that is just what you get when you feed the water into the boiler by spurts. You get the same action that a swinging load on the plant would cause. If you don't believe this, try it out. Take a reading on the flow meter, then open your feed valve wide and watch the flow meter—drops back, doesn't it? Now, close the feed valve and watch the flow meter—jumps right up, perhaps to a greater reading than you had at the start. Just the same action when you open the valve as if the station load would suddenly drop and the fireman had to cut back on his fires, only in this case the boiler stops steaming so fast, but you are using the same amount of fuel oil in the furnace. If the water is fed regularly, the flow-meter chart will not show any sudden swings and your shift efficiency will thus get the benefit.

Carry Water Level at Half a Glass.

Did you, Mr. Watertender, ever stop to think that by carrying the water level constant at half a glass, your work is made easier and you are in a position to help the fireman out? A sudden demand comes for more steam. All right, you have a half-glass of water, a little extra, so you can shut the feed valve a minute—just long enough so that the boiler output increases because you are not putting cold water into it, but that minute gives the fireman a chance to get his steam pressure up. You can now open the feed a little—very gradually, remember too fast will cause the steam to drop again—and slowly work your water levels up to half-glass again.

This little extra work on your part has kept the steam from getting away down so that both you and the fireman would have had to work for perhaps an hour to get it up. Now, suppose your water levels are back to half a glass again, and the fireman is carrying his steam high so as to get the best efficiency; a little load drops off, a boiler pops. All right; once more you can save. The boiler popping can stand a little more water; you open the feed valve. The popping stops almost immediately. The extra water you let in had to be heated. You have saved the steam that was going to waste through the pop valve. The fireman has now cut back on his fires a little so you can regulate the feed again until you have the half-glass of water showing in the gage.

Blowing Down the Boilers.

It is you, Mr. Watertender, who is responsible for blowing down the boilers—for keeping the concentrate in the boilers below 200 so that the boilers

will not prime. It is you who must keep the concentrate as near 200 as possible, so that heat will not be wasted by too much blowing down. Every time a boiler is blown down unnecessarily, it means a loss of approximately ten gallons of oil.

When a boiler is on stand-by, it is you, Mr. Watertender, who should report it in writing to the fireman if the boiler keeps filling up so you have to blow it down to keep the glass from getting too full. It is you who should report it to the fireman if the stand-by boiler keeps losing water so you have to open the feed valve to keep the water in sight in the glass. In both these cases hot water is being wasted and you are in a position to catch these wastes before anybody else. A barrel of water wasted in either of these cases means a gallon of oil lost.

It is you, Mr. Watertender, who must blow down the water column and gage glass on each boiler at least once a shift so that you are sure the water level shown is correct. Otherwise these lines may become clogged, the glass show water and still the boiler go dry, perhaps explode, kill someone and wreck the plant. [W. E. S.]

Sugar Cane Experiments in the Leeward Islands.

The Imperial Department of Agriculture for the West Indies has recently issued a report summarizing the results obtained from Sugar Cane Experiments conducted in Antigua and St. Kitts-Nevis in the season of 1918–19. The report is divided into two parts. Part I is devoted to experiments with varieties of sugar cane, while Part II deals with the results obtained from manurial experiments.

We give below the conclusions they have arrived at from the results of their manurial experiments:

Summary of Conclusions Drawn From Manurial Experiments in the Leeward Islands, 1891 to 1916.

In the Report on Manurial Experiments with Sugar Cane for 1915–16, Dr. Tempany has given (pp. 49–52) a general summary of the whole of the results achieved in the Leeward Islands up to the year 1915. The main conclusions may be outlined as follows:

A. Plant Canes.

1. Pen manure, applied at the rate of 20 tons per acre, gives a remunerative increase of the cane crop.
2. Any addition of pen manure above the amount stated does not produce further remunerative increase.
3. The addition of artificial fertilizers to the basal dressing of 20 tons of pen manure per acre does not result in further remunerative increase.

4. The limiting factor in the growth of the cane crop is, on the whole, its water supply.
5. It is essential for the maintenance of a high degree of fertility in the cane field soils that the percentage of humus in them should be kept at an adequate figure; this is achieved by the addition of pen manure of the amount above mentioned.
6. Phosphatic manures appear to have little beneficial effect on the yield of plant cane in the Leeward Islands.
7. Lime applied to heavy clay cane soils is beneficial in that it ameliorates the texture of the soil and so improves many of the growth conditions.

   Lime, applied in small dressings with a view to correcting soil acidity, seems to have little beneficial effect. This subject, however, is still under investigation, and no conclusive statements can yet be made.
8. Molasses, applied as a manure to plant canes, gives appreciable increase in yields.

B. Ratoon Canes.

The general conclusions drawn from experiments on the manuring of plant canes hold good also for ratoon canes, with the following qualifications:

1. Early applications of quick-acting nitrogenous manures, such as sodium nitrate, ammonium sulphate, and calcium nitrate, in dressings conveying about 40 pounds of nitrogen per acre to the cane soils, have a beneficial effect in stimulating the growth of new stems from the old stools, especially during seasons of normal or high rainfalls.
2. Molasses seems to be of little value in increasing the yield of ratoon canes.
3. Intertillage is beneficial when applied in the early stages of growth of ratoon canes.
4. Manures, applied to plant canes or to first ratoon canes, may exert an appreciable effect on succeeding crops of first ratoons and second ratoons, respectively.

The results of the 1915–16–17 experiments with plant canes led to conclusions which, on the whole, did not differ markedly from those already drawn from the long series of experiments carried out between 1891 and 1915. It was decided, therefore, in 1917, to discontinue the experiments and to inaugurate in their place another series, the aim of which was to concentrate on the essential features which have emerged, and to secure by means of an increased number of repetitions of each experiment, in each season, a more rapid accumulation of results. (See Report on Sugar Cane Experiments in the Leeward Islands for 1915–16, p. 52.)

RESULTS OF THE NEW SERIES OF MANURIAL EXPERIMENTS WITH SUGAR CANE AT ST. KITTS IN 1917–18, AT BRIGHTON ESTATE.

Manurial Treatment	Plot	Tons Cane per Acre	Mean	Percentage Gain Over No Manure
1. No Manure	1 a	22.5	16.4	....
	1 b	14.6		
	1 c	16.2		
	1 d	13.5		
	1 e	17.1		
	1 f	14.8		
2. Pen Manure, 20 tons per acre..	2 a	24.3	23.4	+ 42.7
	2 b	25.2		
	2 c	25.2		
	2 d	17.8		
	2 e	24.9		
	2 f	23.1		
3. 40 lbs. nitrogen as sulphate of ammonia, with potash and phos phate	3 a	30.3	25.3	+ 54.3
	3 b	27.7		
	3 c	27.0		
	3 d	23.4		
	3 e	19.6		
	3 f	24.0		
4. 60 lbs. nitrogen as sulphate of ammonia, with potash and phos phate	4 a	29.3	26.0	+ 58.5
	4 b	23.2		
	4 c	25.9		
	4 d	21.6		
	4 e	25.6		
	4 f	20.4		
5. 40 lbs. nitrogen as nitrate of soda, with potash and phosphate......	5 a	24.7	26.3	+ 60.3
	5 b	30.8		
	5 c	26.1		
	5 d	25.0		
	5 e	22.0		
	5 f	29.0		
6. 60 lbs. nitrogen as nitrate of soda, with potash and phosphate......	6 a	23.0	25.1	+ 53.0
	6 b	24.1		
	6 c	24.9		
	6 d	21.3		
	6 e	32.2		
	6 f	25.2		
9. 60 lbs. nitrogen as sulphate of ammonia, without potash and phosphate	7 a	23.6	21.1	+ 28.6
	7 b	22.2		
	7 c	20.9		
	7 d	18.0		
	7 e	23.2		
	7 f	18.4		

Manurial Treatment	Plot	Tons Cane per Acre	Mean	Percentage Gain Over No Manure
10. 60 lbs. nitrogen as nitrate of soda, without potash and phosphate...	8 a	19.1	17.1	+ 4.3
	8 b	12.8		
	8 c	20.9		
	8 d	16.9		
	8 e	14.8		
	8 f	18.0		
12. Filter-press cake 2 tons per acre..	9 a	14.2	14.8	— 9.8
	9 b	17.8		
	9 c	17.7		
	9 d	11.3		
	9 e	15.8		
	9 f	12.2		
13. Cotton-seed meal 600 lbs. per acre.	10 a	20.2	17.3	+ 5.5
	10 b	19.5		
	10 c	16.9		
	10 d	10.8		
	10 e	21.6		
	10 f	14.8		

The following conclusions may perhaps legitimately be drawn from the results of this new series of experiments:

1. The manures applied may be grouped into three classes: (a) quick-acting nitrogenous plus potash and phosphate (Nos. 3, 4, 5, and 6); (b) quick-acting nitrogenous manures *without* potash and phosphate (Nos. 9 and 10); and (c) organic manures (Nos. 2, 12, and 13).

2. The highest increase in the mean yields of the manured plots has been given by combinations of quick-acting nitrogenous manures plus potash and phosphate (Nos. 5, 4, 3, and 6, arranged in order of magnitude of increase produced).

3. Pen manure has given an increase almost as large as that due to the combinations mentioned in the last paragraph.

4. In the absence of potash and phosphate, quick-acting nitrogenous manures have not given marked increase in yield.

5. The organic manures—filter-press cake and cotton seed meal—have either depressed the yield, or have increased it to an insignificant amount. This result is difficult to interpret, and it would be unwise to discuss its meaning until a continuation of the experiments has furnished further evidence.

It appears that the most profitable manure to use for plant canes in St. Kitts, *in the absence of pen manure,* is a complete manure supplying per acre about 40 pounds of nitrogen contained either in ammonium sulphate or sodium nitrate, together with potassium sulphate (to supply 60 pounds of K_2O) and basic slag (to supply 40 pounds of P_2O_5).

Apparently, from the results of the season's experiments, potash is a very important ingredient. Phosphate, perhaps, is of less value as has been shown

in the combined results of manurial experiments carried out over a great number of years.

Further results of experiments along the above lines may in future years confirm the generalizations set out in the above statements. Especially may they be hoped to throw new light on the question of the importance of potash as a constituent of a general artificial manure to replace pen manure in manuring the cane crop in St. Kitts.

J. A. V.

Clarification of Cane Juice for the Manufacture of White Sugar, Using Magnesium Acetate.*

Mr. Migaku Ishida, of the Sugar Experiment Station, Formosa, has published a bulletin[1] in which he proposes a new method of juice clarification for white sugar manufacture, called by him the "double ammonio-defecation process." His method of operating is to heat raw juice, treat with ammonia and magnesium acetate, subside, treat with milk of lime, and again subside. This procedure is said to raise the purity about 7°, "the expense in the sugar factory per picul of sugar being about one-third of the ordinary carbonatation process." The quality of the sugar produced by the new process is said to be "better than No. 25 of the Dutch standard, and nearly the same as that of the double carbonatation process, and better than that produced by sulphitation"; while the yield is stated to be, if not higher, certainly not lower than in other processes. Some extracts from this publication (which is the first technical bulletin in English issued by the Formosa Station) may be made.

Laboratory Experiments.

The writer's first plan was to improve the ordinary defecation process; and with this purpose in view the effect of several reagents was tried, the best results being obtained with ammonia and ammonium acetate, followed by lime. It was intended to employ some colloidal substance, as aluminum or magnesium hydroxide, which could be prepared from the sulphate by the use of ammonia or other alkali; and it was finally decided to utilize a magnesium compound, "as it is readily obtainable and at a low cost."

This new method of forming magnesium hydroxide in the juice seemed to be very efficient in its clarifying action. A 15 per cent solution of ammonia, and a 1.81 per cent solution of magnesium acetate, were prepared; and a number of experiments carried out, some of the conclusions from which are as follows: (1) Caramel is removed from its solution by these reagents, 75 c.c. of a solution of caramel being treated with 3 c.c. of ammonia (15 per cent), and 10

* From International Sugar Journal, May, 1921.

1 Bulletin No. 1, entitled "A Contribution to the Chemistry of the Clarification of Cane Juice and of Sugar Manufacture," by Migaku Ishida, published by the Government Sugar Station, Formosa, Japan. It contains 62 pages.

c.c. of magnesium acetate (1.81 per cent), boiled and filtered, when on examining the degree of color in the Stammer instrument it was concluded that caramel had been eliminated. (2) Solutions of dextro-rotatory amino-acids, and of amino-acid amides, are rendered optically inactive. (3) Glucose in the proportion in which it occurs in cane juice is not affected by the new treatment, nor is levulose.

Incidentally, it occurred to the writer that the proposed reagents might be applied as a clarifying treatment in the analysis of raw cane juices, the procedure being to take 50 c.c. of juice and add 10 c.c. of magnesium acetate (1.81 per cent), and 5 c.c. of ammonia (15 per cent), to complete to 100 c.c. with water, and to filter. As a control, 2 c.c. of basic lead acetate were added to 50 c.c. of the same juice, the volume made up to 100 c.c., and the liquid filtered. The polarization in both cases was the same, viz., 19.70.

In the laboratory experiments on the application of magnesium acetate as a possible technical process, lime was not used at first. In one of the experiments, 0.14 c.c. of 15 per cent ammonia, and 0.28 c.c. of 1.82 per cent magnesium acetate solution, were added to every 100 c.c. of the raw juice. Originally the purity was 78.80, but this treatment raised this value to 82.26°. Less satisfactory results were obtained with smaller amounts of the reagents.

Later, however, it was observed that a further improved effect could be realized by the use of lime after adding the two reagents. For example, in one of the writer's experiments 500 c.c. of raw juice heated to 80° C. were treated with the reagents at the rate of 0.08 c.c. of ammonia, and 0.25 c.c. of magnesium acetate solution per 100 c.c., and allowed to subside an hour. At the end of this time the clear liquid was drawn off, treated with milk of lime (15° Bé.) at the rate of 0.4 c.c. per 100 c.c. of juice. Another lot of 500 c.c. of the same juice was submitted to ordinary defecation, by adding 2 c.c. of milk of lime 15° Bé.), and heating to boiling point, and subsiding. These were the results obtained:

	Brix	Polarization	Purity
Raw cane juice..............	17.9	13.8°	77.09
Ordinary defecation	18.8	15.0°	79.79
New double clarification	18.0	15.3°	85.00

Other tests showed that the effect of the new process was to remove 80 per cent of the pectins and gums, 25 per cent of the nitrogenous substances, and about 30 per cent of the ash. Calcium oxide increased about 60 per cent of that originally present in the raw juice.

Application on the Factory Scale.

It is pointed out that in applying these reagents to factory practice, only a few additions to the ordinary equipment would be necessary, viz., more subsiding tanks and a set of Danek filters for the syrup.

The writer proposes to prepare the ammonia from ammonium sulphate and calcium hydroxide (using an apparatus similar to that of Grueneberg); while

magnesium acetate would be made from the carbonate and acetic acid, keeping the liquid alkaline to litmus.[2] Concluding, it is stated that "this new process has proved its worth theoretically and practically, and has been shown to be easily applicable to the ordinary raw sugar factory. Its reagents . . . . . can be prepared in any sugar factory. Besides, the yield is not low (no inversion occurring), and the sugar produced is of a high grade, while neither the expense of the clarifying agents nor the cost of production exceeds that of other processes." [J. A. V.]

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[2] Magnesium carbonate is quoted on the London market today at about £30 per ton, f. o. b., including packages; and acetic acid (80 per cent) at about £48 per ton.—[Editor I. S. J.]

SUGAR PRICES FOR THE MONTH

Ended July 15, 1921.

	96° Centrifugals		Beets	
	Per Lb.	Per Ton.	Per. Lb.	Per Ton.
(June 16, 1921)	4.00c	$ 80.00	No quotation	
" 21	4.25	85.00		
" 23	4.00	80.00		
" 28	4.28	85.60		
" 29	4.00	80.00		
" 30	4.3125	86.25		
*July 1	4.625	92.50		
** " 5	4.3125	86.25		
" 6	4.3125	86.25		
" 7	4.1875	83.75		
" 11	4.375	87.50		
" 14	4.5992	91.984		
" 15	4.50	90.00		

* Covers a purchase for export purposes and does not reflect regular domestic consumption market.

** July 5th information one sale four cents, another 4.625; latter export.